Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins

Part 6: Upper Willamette Chinook

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I. ESU Overview and Historical Range

The UW chinook ESU consists of seven populations as shown in **Error! Reference source not found.**. All the populations in the ESU are in a single stratum since they share a similar life history pattern (spring run) and a single ecozone (McElhany et al. 2003, Myers et al. 2006).

Spring chinook in the Willamette basin are extremely depressed. Historically, the spring run of chinook may have exceeded 300,000 fish (Myers et al. 2003). However, not only is the current ESU abundance of wild fish less than 10,000 fish, but only in two locations (McKenzie and Clackamas) does significant natural production occur. This ESU has been adversely impacted by the degradation and loss of spawning and rearing habitat associated with hydropower development as well as by interactions with the large number of natural spawning hatchery fish. Further, only in recent years has it been possible to separately identify hatchery and wild fish, thereby making the assessment of natural spring chinook populations feasible.

The presentation of our assessment begins with three sections, each of which evaluates one of the viability criteria (i.e., abundance/productivity, spatial structure, and diversity). This is then followed by a synthesis section where we pool the results from these criteria evaluations into a status rating for each population. The methods are described in Part 1 of this report. We end our presentation with an interpretation of the population results in terms of the overall status of this ESU.
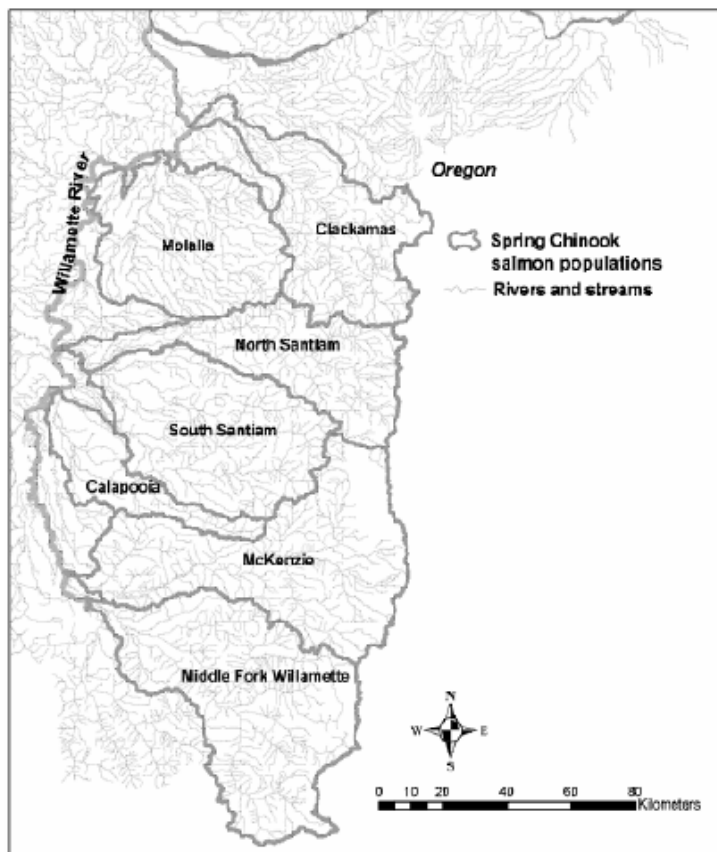

Figure 1: Map of populations in the Upper Willamette chinook ESU.

II. Abundance and Productivity

A&P – Clackamas

A time series of abundance sufficient for quantitative analysis is available for the Clackamas spring run population (Appendix B). Descriptive graphs and viability analysis results are provided in Figure 2 to Figure 8 and in **Error! Reference source not found.** to Table 4. The population long-term geometric mean is about 900 natural origin spawners, which is in the moderate risk minimum abundance threshold category (**Error! Reference source not found.**). The impact of fisheries on this population has resulted in an average mortality rate of 35% in recent years. However, there is considerable uncertainty in these mortality rate estimates. Therefore estimates of pre-harvest population productivity, which incorporates these fishery impact rates, are also likely to be imprecise. The pre-harvest viability curve analysis, the CAPM modeling and the PopCycle modeling all suggest that the population is currently viable. The escapement viability curve suggests that a population experiencing the pattern of harvest that occurred over the available time series would most likely be in the moderate risk category. One characteristic of all spring chinook salmon populations we assessed is that there appears to be a high rate of pre-spawning mortality which is an increased risk factor (the effective abundance is lower than estimated by spawner counts). For the Clackamas it has been estimated about 20% of the females die before spawning (Figure 9). The Oregon Native Fish Status report (ODFW 2005) listed the Clackamas spring chinook population as a "pass" for abundance and a "fail" for productivity.

Although there is considerable uncertainty in the analysis of this population for the A&P criterion, we conclude the most probable classification for this population under the A&P criterion is the low extinction risk category.
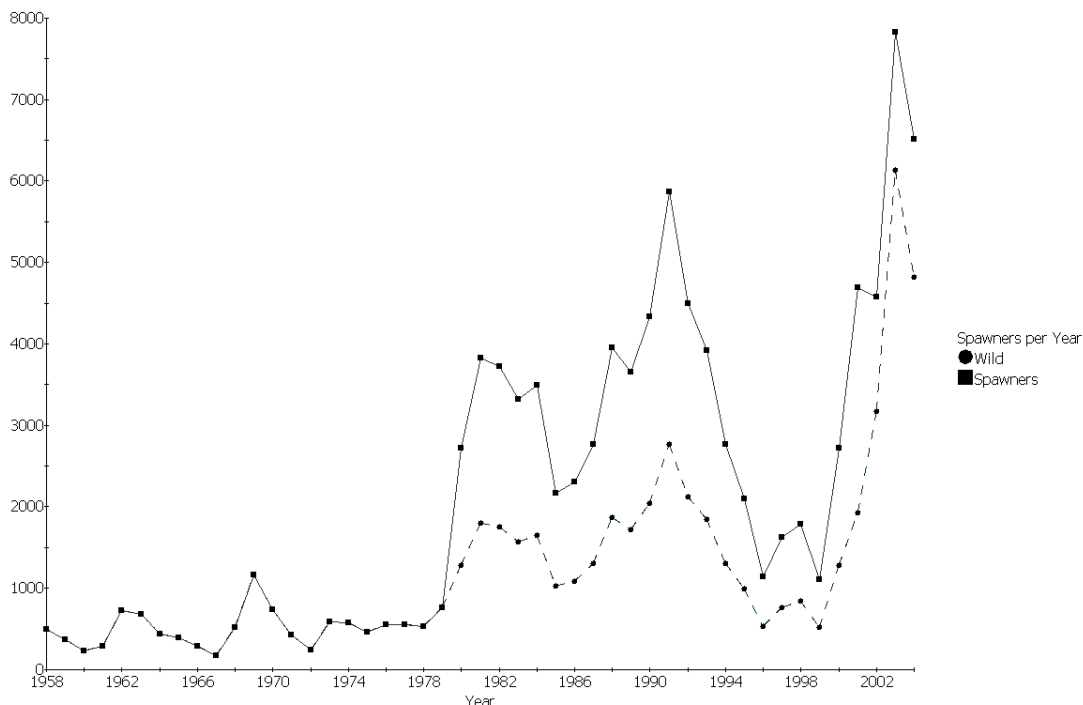
Figure 2: Clackamas River spring chinook abundance.
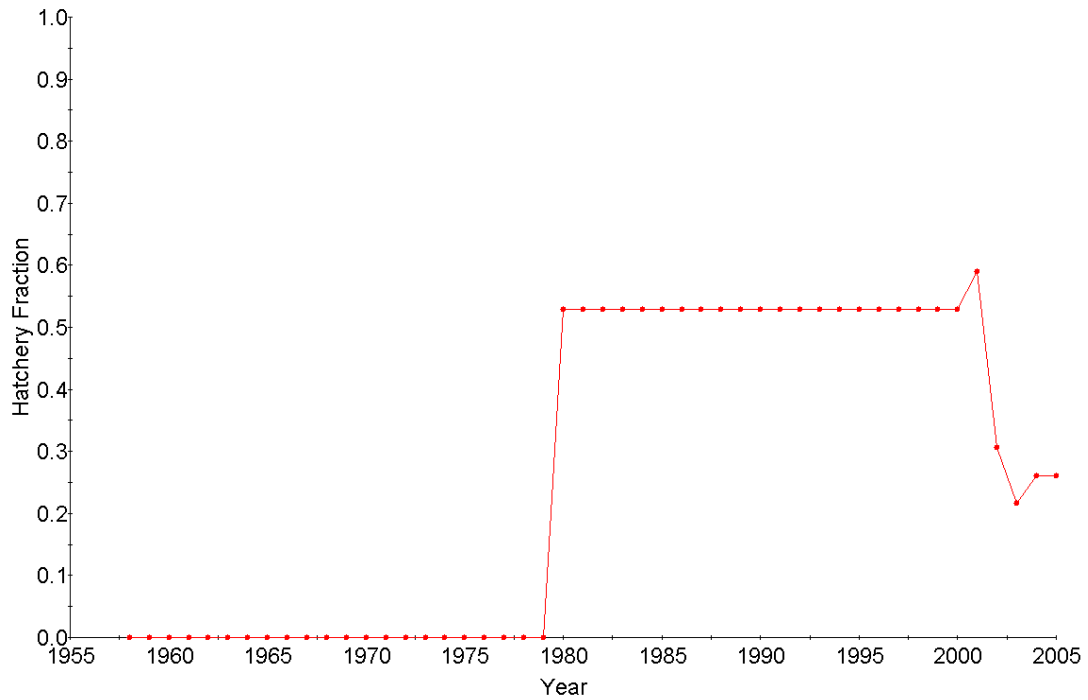
Figure 3: Clackamas River spring chinook hatchery fraction.
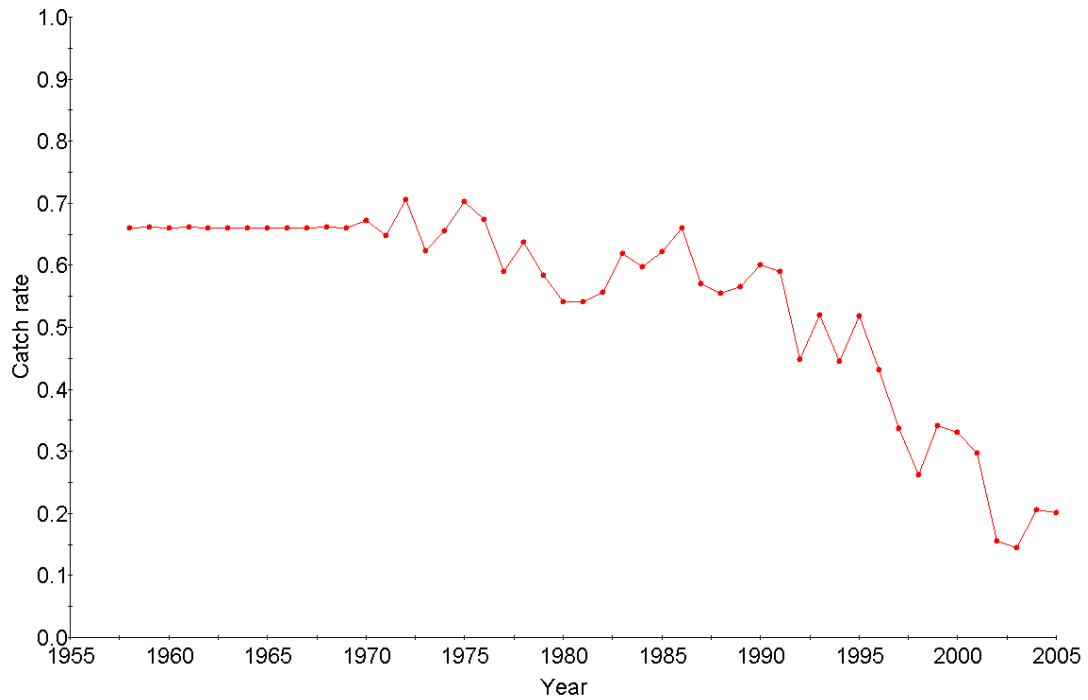
Figure 4: Clackamas River spring chinook harvest rate.
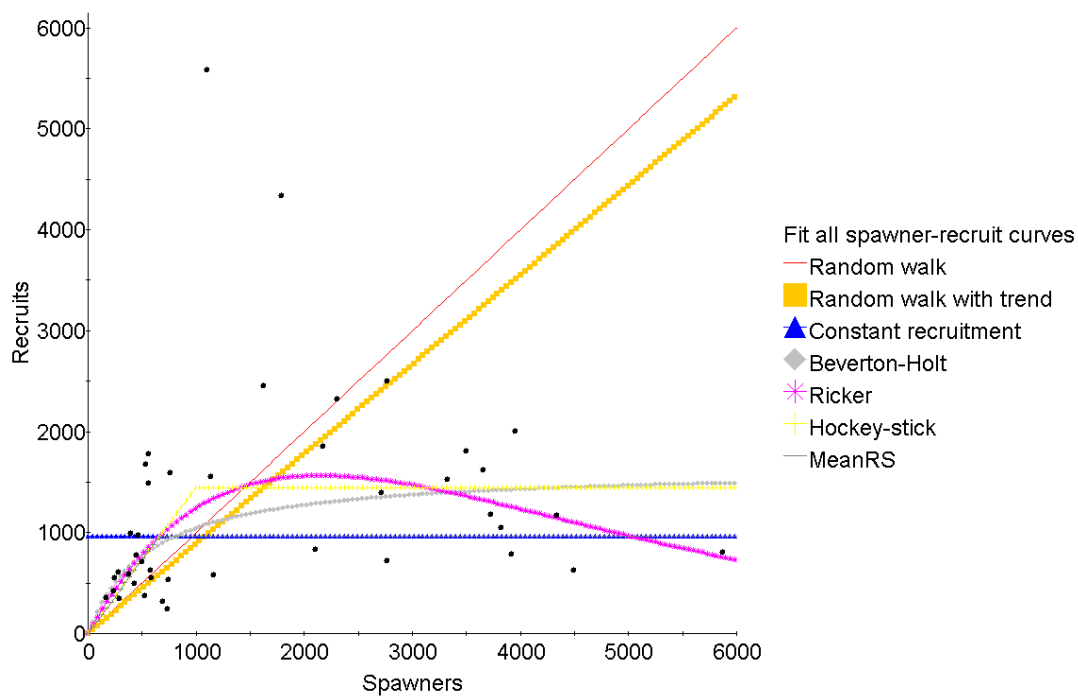
Figure 5: Clackamas River spring chinook escapement recruitment functions.
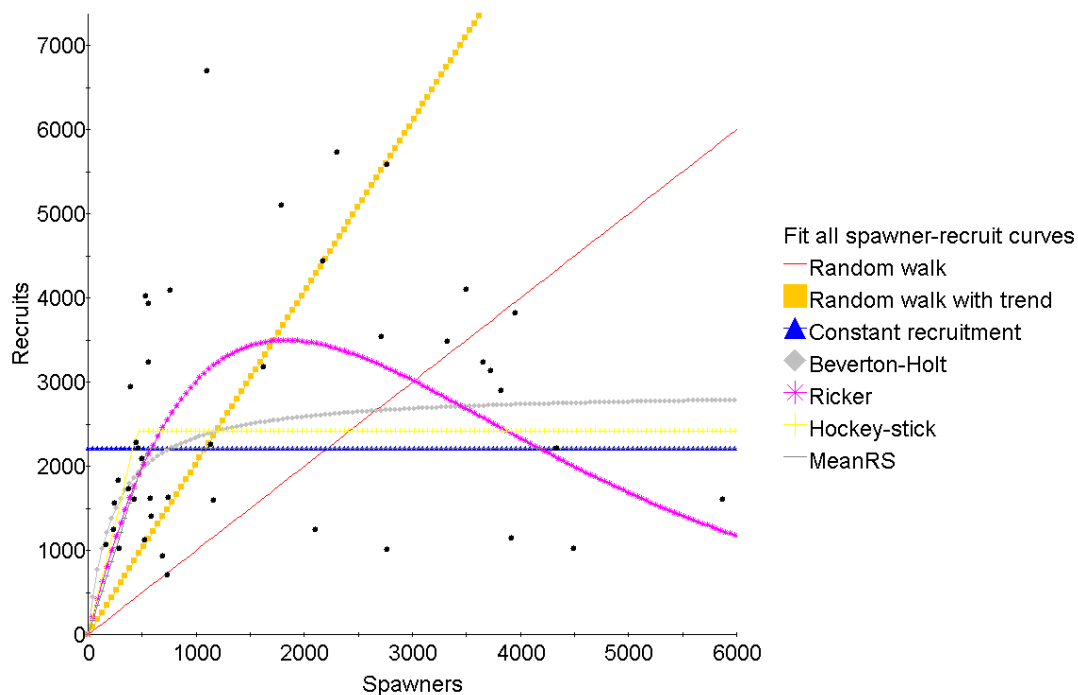
Figure 6: Clackamas River spring chinook pre-harvest recruitment functions.

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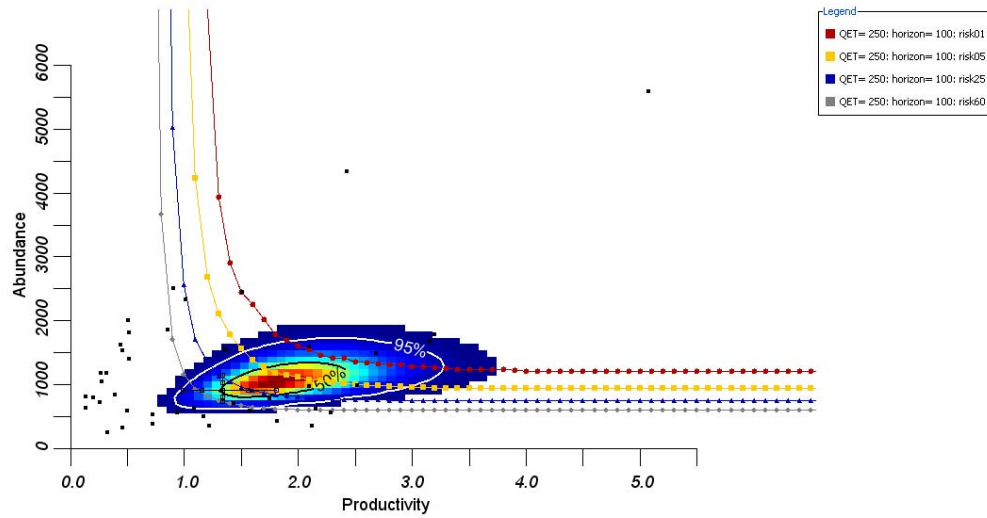
Figure 7: Clackamas River spring chinook escapement viability curve.

Figure 8: Clackamas River spring chinook pre-harvest viability curve.

Figure 9: Spring chinook pre-spawning mortality in the Clackamas based on carcass surveys of the fraction of female fish that died prior to spawning (Schroeder et al. 2005).

Table 1: Clackamas River spring chinook summary statistics. The 95% confidence intervals are shown in parentheses.

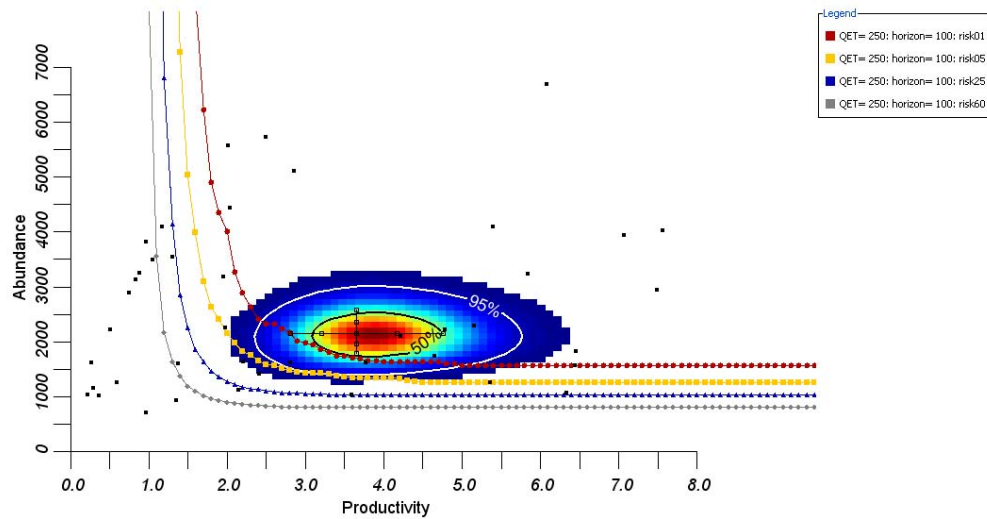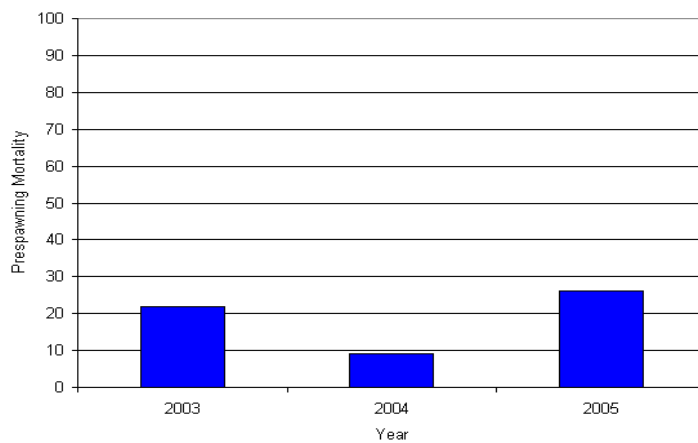| Statistic	Escapement		Pre-harvest	
	Total Series	**Recent Years**	**Total Series**	**Recent Years**
Time Series Period	1958-2005	1990-2005	1958-2005	1990-2005
Length of Time Series	48	16	48	16
Geometric Mean Natural Origin Spawner Abundance	902 (713-1141)	1656 (1122-2443)	NA	NA
Geometric Mean Recruit Abundance	968 (775-1210)	1385 (790-2428)	2216 (1848-2657)	2048 (1266-3313)
Lambda	0.967 (0.849-1.102)	0.902 (0.422-1.929)	1.151 (0.995-1.331)	0.958 (0.487-1.886)
Trend in Log Abundance	1.044 (1.033-1.055)	1.048 (0.965-1.139)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.888 (0.667-1.182)	0.555 (0.221-1.395)	3.8 (2.95-4.897)	0.82 (0.359-1.874)
Geometric Mean Recruits per Spawner (broods < median spawner abundance)	1.462 (1.102-1.94)	1.174 (0.365-3.782)	1.044 (1.033-1.055)	1.566 (0.528-4.644)
Average Hatchery Fraction	0.266	0.466	NA	NA
Average Harvest Rate	0.543	0.364	NA	NA
CAPM median extinction risk probability (5th and 95th percentiles in parentheses)	NA	NA	0.000 (0.000-0.025)	NA
PopCycle extinction risk	NA	NA	0.02	NA

Table 2: Escapement recruitment parameter estimates and relative AIC values for Clackamas spring chinook. The 95% probability intervals on parameters are shown in parentheses. The "best" approximating model (relative AIC=0) is shown in bright green. Models nearly indistinguishable from best (relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (relative AIC > 10) are not highlighted (i.e., white background).

| Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.91 (0.78-1.13)	36.4
Random walk with trend	0.89 (0.71-1.16)	NA	0.91 (0.79-1.14)	37.7
Constant recruitment	NA	968 (815-1185)	0.71 (0.61-0.89)	16.6
Beverton-Holt	2.9 (1.98-8.07)	1634 (1140-2301)	0.59 (0.53-0.77)	4.5
Ricker	1.98 (1.59-2.53)	1564 (1369-1900)	0.57 (0.5-0.72)	0
Hockey-stick	1.45 (1.22-2.23)	1446 (1080-1839)	0.59 (0.52-0.77)	4.4
MeanRS	1.46 (1.17-1.79)	968 (811-1164)	0.39 (0.24-0.55)	43.8

Table 3: Pre-harvest recruitment parameter estimates and relative AIC values for Clackamas spring chinook. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.21 (1.04-1.5)	66.7
Random walk with trend	2.03 (1.61-2.72)	NA	0.98 (0.85-1.24)	51.2
Constant recruitment	NA	2217 (1920-2609)	0.58 (0.5-0.72)	6.1
Beverton-Holt	12.19 (7.75-27.39)	2901 (2315-3647)	0.53 (0.47-0.68)	1.7
Ricker	5.2 (4.27-6.52)	3496 (3102-4111)	0.52 (0.46-0.67)	0
Hockey-stick	5.32 (4.14-26.21)	2422 (1999-2891)	0.54 (0.48-0.7)	3
MeanRS	4.02 (3.26-4.88)	2216 (1918-2567)	0.3 (0.21-0.39)	55.9

Table 4: Clackamas spring chinook CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in 'Extirpated or nearly so' category	0.971	1.000	1.000
Probability the population is above 'Moderate risk of extinction' category	0.843	1.000	1.000
Probability the population is above 'Viable' category	0.475	0.996	0.983
Probability the population is above 'Very low risk of extinction' category	0.106	0.895	0.818
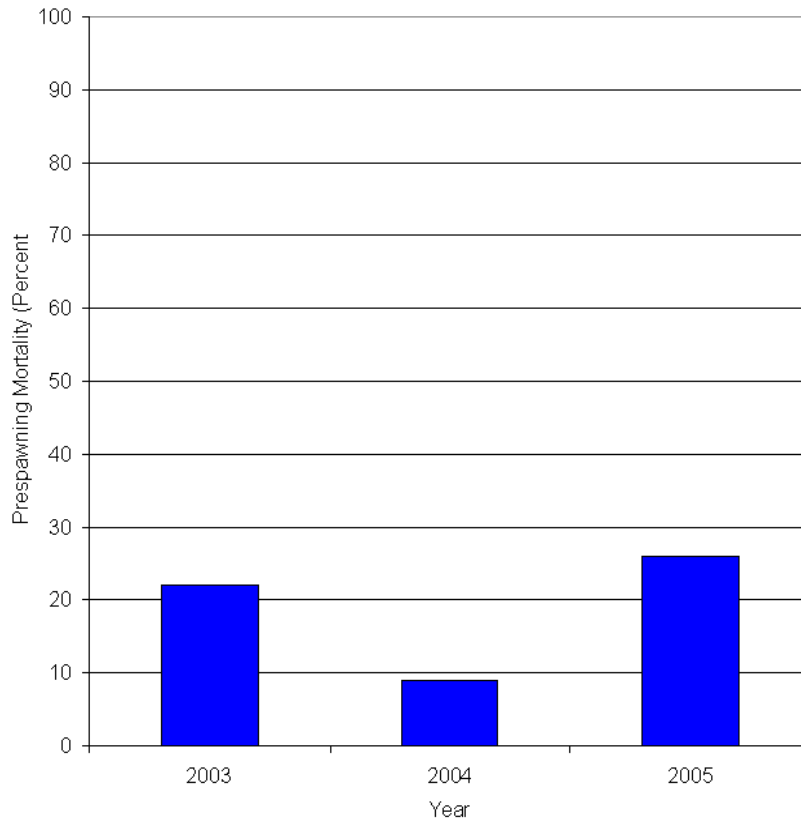
Figure 10: Estimated pre-spawning mortality of spring chinook in the Clackamas River upstream of North Fork Dam. Based on carcass survey (Schroeder et al. 2005).
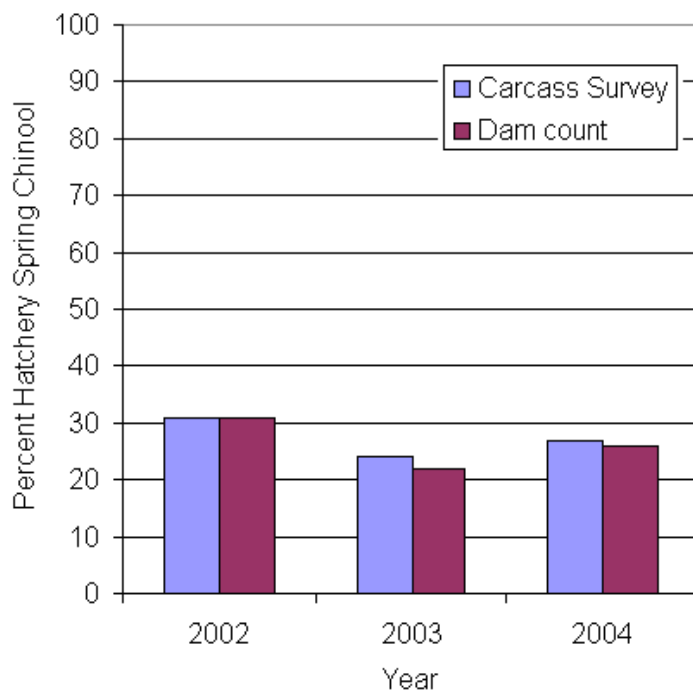
Figure 11: Percent of hatchery origin spring chinook spawners in the Clackamas River upstream of North Fork Dam base on two different estimation methods (Schroeder et al. 2005).

A&P – Molalla

Recent spawning surveys indicate a relatively low density of spawning in the Molalla (Figure 12). Of those fish returning, nearly all are of hatchery origin
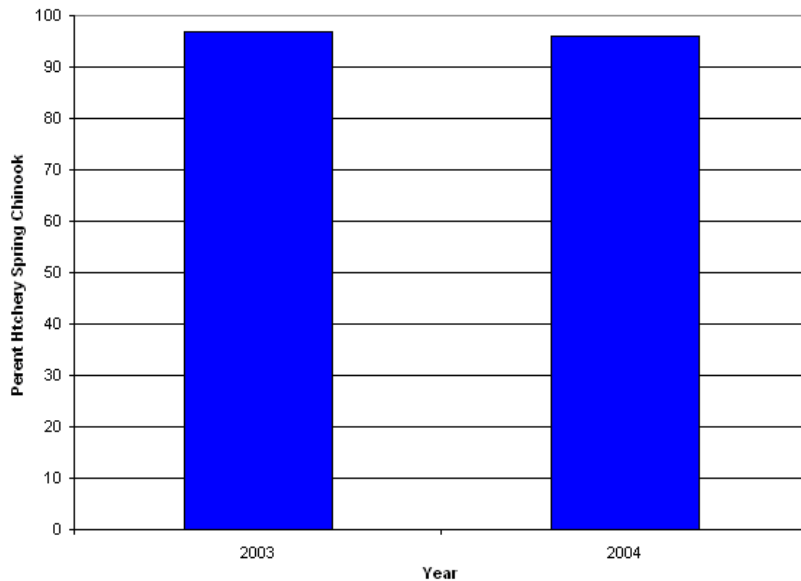
(
Figure 13). Pre-spawning mortality in 2003 in the Molalla was estimated at 69% (9 of 13 female carcasses recovered still contained eggs and therefore indicated pre-spawning mortality). Taken together, these data indicate little, if any, natural production of spring chinook in the Molalla. Based on this evidence, this population under the A&P criterion is most likely at very high extinction risk. The Oregon Native Fish Status report (ODFW 2005) listed the Molalla spring chinook population as a "fail" for abundance and a "fail" for productivity.
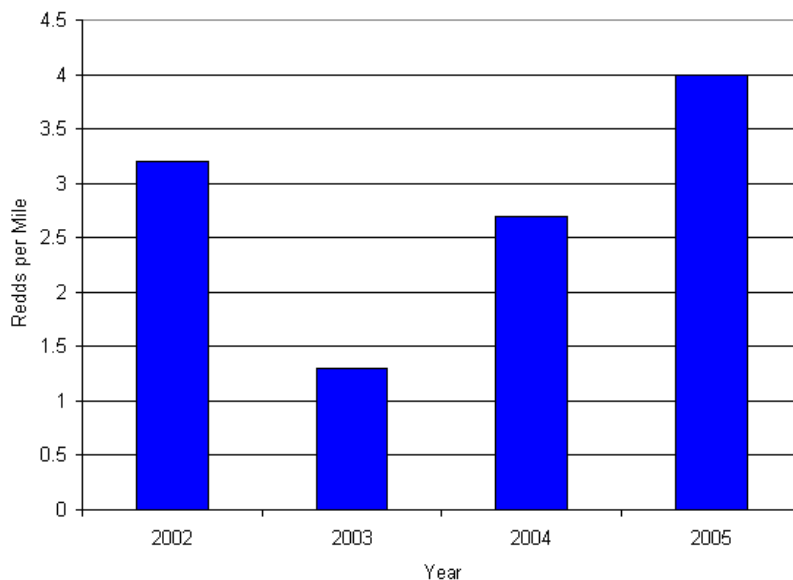
Figure 12: Spring chinook redds per mile in Molalla River surveys (Schroeder et al. 2005).
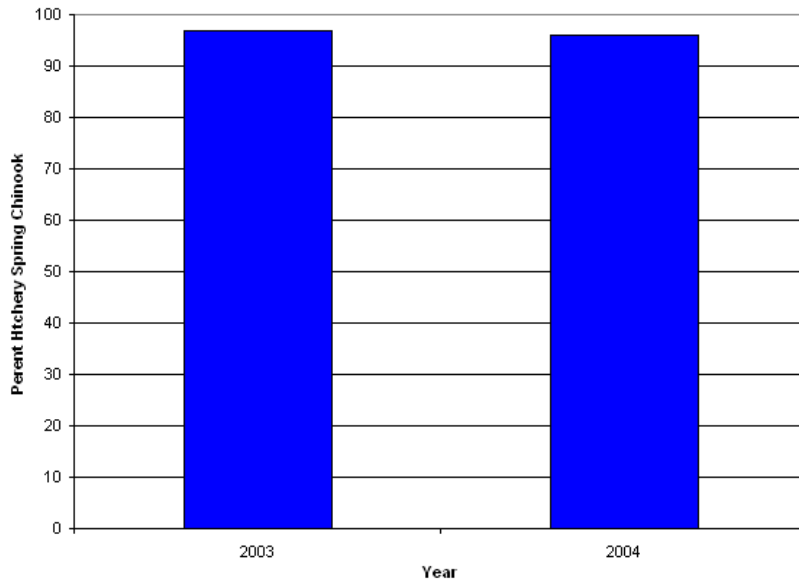
Figure 13: Percent hatchery origin spring chinook spawners in the Molalla River (Schroeder et al. 2005).

A&P – North Santiam

Recent redd survey results for the North Santiam are show in Figure 14 and Table 5. These indicate a relatively low redd density in this population. Of the fish that return nearly all are of hatchery origin (Figure 15). In addition there is a high estimated pre-spawning mortality (Figure 16). Although the pre-spawning mortality estimates are not considered very precise, it appears that more than half the females that return to the river die before spawning. Taken together, these data indicate little, if any, natural production of spring chinook in the North Santiam. Based on this evidence, this population under the A&P criterion is most likely at very high extinction risk. The Oregon Native Fish Status report (ODFW 2005) listed the North Santiam spring chinook population as a "fail" for abundance and a "fail" for productivity.
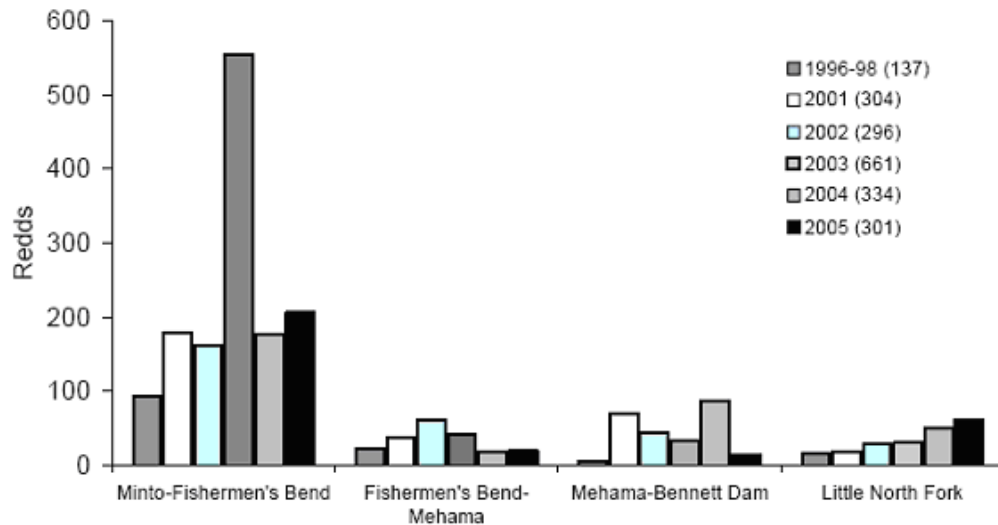
Figure 8. Spring Chinook salmon redds counted in four areas of the North Santiam basin upstream of Bennett dams, 1996–1998 average and 2001–2005. Total redds counted in the basin are in parentheses in the legend.

Figure 14: Number of Redds counted in sections of the North Santiam River. Copied from Schroeder et al. (2005).

Table 5: Redds per mile in sections of the North Santiam River. Copied from Schroeder et al. (2005).

Table 8. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2005, and comparison to redd densities in 1996–2004. Spawning in areas downstream of Stayton may include some fall Chinook.

Survey section	Length (mi)	Counts Carcass	Counts Redd	Redds/mi 2005	2004	2003	2002	2001	2000	1999	1998	1997	1996
Minto–Fishermen's Bend	10.0	145	206	20.6	17.7	55.5	16.2	17.9	23.0[a]	15.6	11.8	8.5	7.8
Fishermen's Bend–Mehama	6.5	26	20	3.1	2.8	6.5	9.4	5.7	5.8	3.1	4.3	2.5	3.5
Mehama–Stayton Is.	7.0	23	14	2.0	12.6	4.7	6.1	10.0	b	--	0.6	0.9	1.0
Stayton Is.–Stayton	3.3	33	24	7.3	7.9	3.6	3.0	6.7	b	--	10.0	3.6	2.0
Stayton–Greens Bridge	13.7	7	4	0.3	0.2	0.1	0.4	0.1	--	0.0	0.4	1.1	0.1
Greens Br.–mouth	3.0	3	0	0.0	0.0	1.7	4.7	--	--	--	4.7	9.7	--
Little North Santiam	17.0	73	61	3.6[f]	3.0[e]	1.8[d]	1.8[c]	1.1[a]	1.3[a]	1.0	2.2[a]	0.6[a]	0.0

[a] Corrected number.
[b] Data was recorded for Mehama–Stayton and density was 0.9 redds/mi.
[c] 400 unclipped adult spring Chinook were released on August 20 and 30, September 5 and 6, 2002.
[d] 268 unclipped adult spring Chinook were released in June (25th), July (9th,15th,22nd), August (25th), and September (2nd,4th).
[e] 377 unclipped adult spring Chinook were released on July 9, August 19 and 27, and September 9.
[f] 329 unclipped adult spring Chinook were released on July 27, August 30, and September 2, 6, 9, and 12.
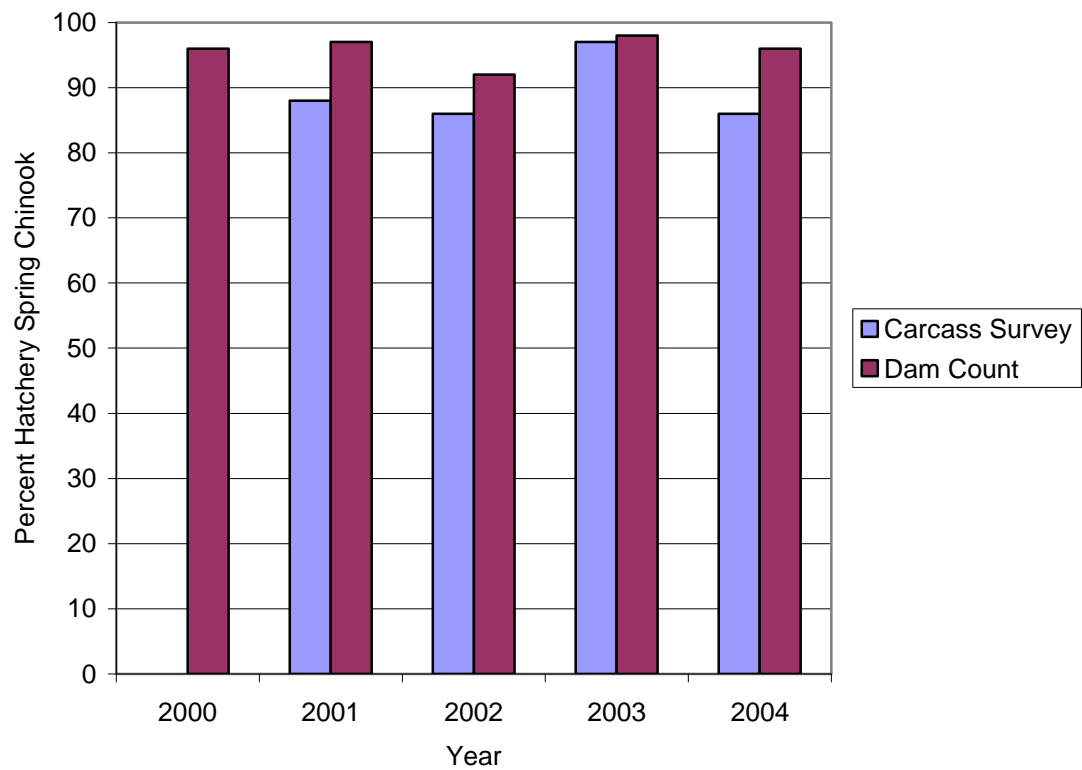
Figure 15: Percent of spring chinook spawners of hatchery origin in the North Santiam. The carcass survey is the region Minto to Bennet Dam, including Little North Santiam. The dam count is Bennet dam trap (Schroeder et al. 2005).
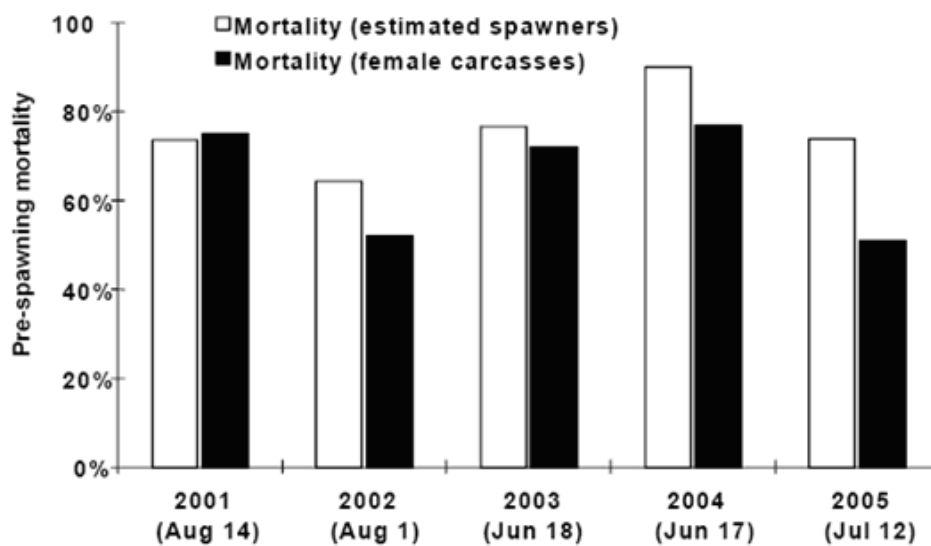
Figure 16: Pre-spawning mortality estimates for the North Santiam River based on two different estimation methods. Copied from Figure 17 in Schroeder et al. (2005).

A&P – South Santiam

Recent redd survey results for the South Santiam are show in Figure 14 and Table 6. These indicate a relatively low redd density for most of the system, but the abundance is higher than in the North Santiam. However, of the fish that return nearly all are of hatchery origin (Figure 18). In addition, estimates for pre-spawning mortality were quite high (Figure 19), although levels in the South Santiam appear lower than in the North Santiam. Taken together, particularly when considering the hatchery fraction, these data indicate little, if any, natural production of spring chinook in the South Santiam. Based on this evidence, this population under the A&P criterion is most likely at very high extinction risk. The Oregon Native Fish Status report (ODFW 2005) listed the South Santiam spring chinook population as a "fail" for abundance and a "fail" for productivity.
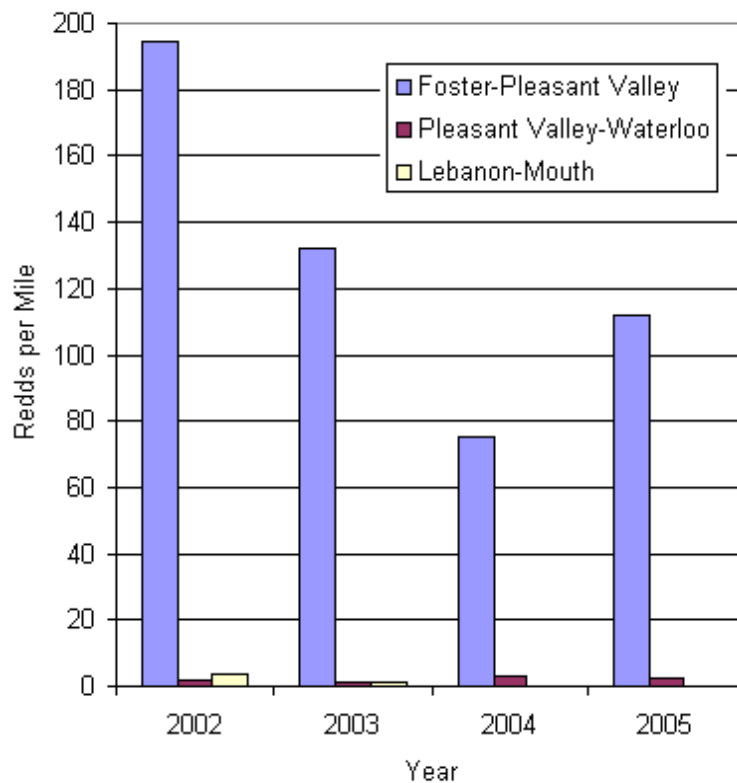
Figure 17: Redds per mile of spring chinook in sections of the South Santiam River. Lengths of the sections are Foster-Pleasant Valley = 4.5 miles, Pleasant Valley-Waterloo = 10.5 miles, and Lebanon-Mouth = 20 miles.

Table 6: Table showing spawning survey results for South Santiam spring chinook. Copied from Schroeder et al. (2005).

Table 14. Summary of Chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, and Molalla basins, 2005.

River, section	Length (mi)	Carcasses Non fin-clipped[a]	Carcasses Fin-clipped	Redds	Redds/mi 2005	2004	2003	2002	1998
Middle Fork Willamette									
Dexter–Jasper	9.0	8	37	9	1.0	1.0	1.5	7.1	1.1
Fall Creek (above reservoir)	16.0	12	c	130	8.1	12.9	6.1	12.9	--
South Santiam									
Foster–Pleasant Valley	4.5	124	401	507	112.7	75.1	132.0	194.4	36.0
Pleasant Valley–Waterloo	10.5	14	68	23	2.2	3.3	1.5	1.8	1.8
Lebanon–mouth	20.0	1	6	--	--	0.2	1.0	3.4	2.9
Molalla									
Horse Cr–Pine Cr[b]	6.2	4	19	25	4.0	2.7	1.3	3.2	--

[a] Otoliths have not yet been read to determine the proportion of wild and hatchery fish.
[b] A segment of the Haybarn Cr–Trout Cr section of which we surveyed 16.1, 11.5, and 16.3 mi in 2004, 2003, and 2002, respectively.
[c] No fin-clipped fish were processed.
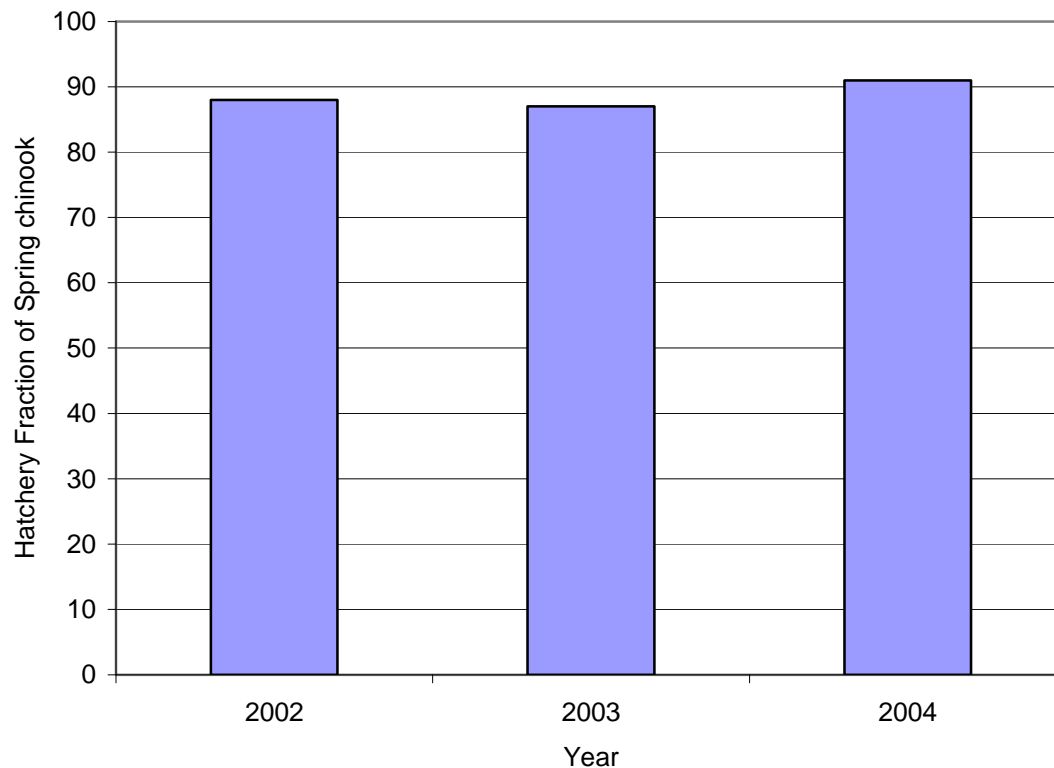
Figure 18: Percent of spring chinook spawners of hatchery origin in the South Santiam (Schroeder et al. 2005). Based on carcass recoveries in the area from Foster to Waterloo.
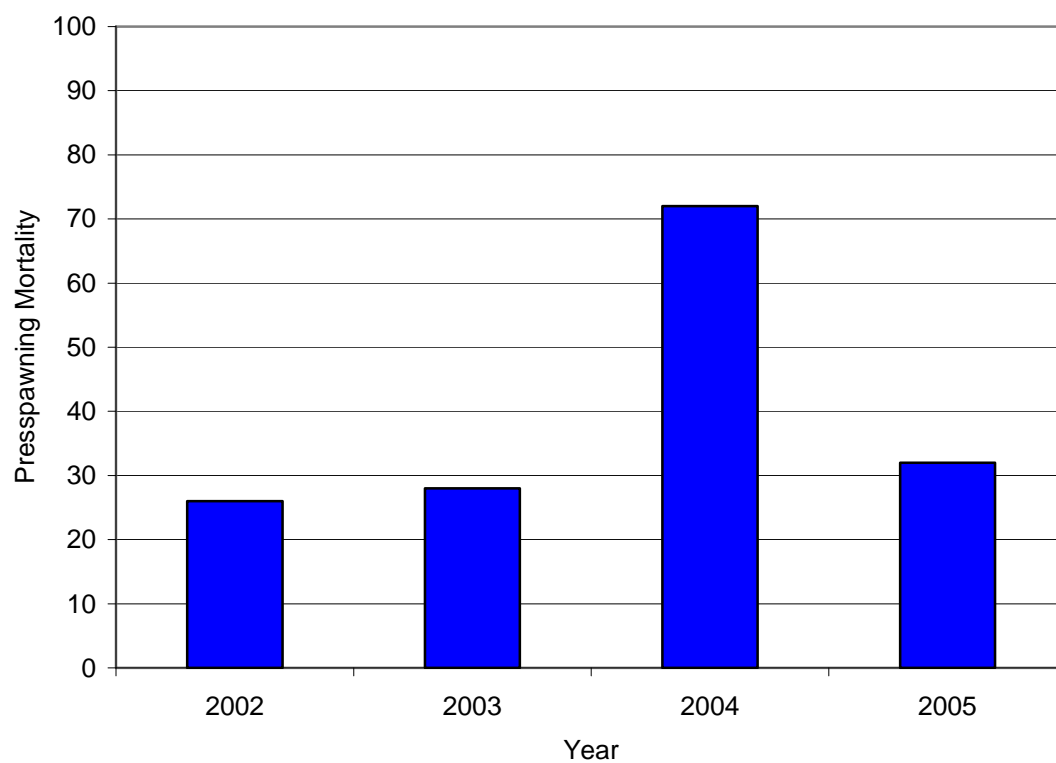
Figure 19: Pre-spawning mortality estimates for the South Santiam River (Schroeder et al. 2005).

A&P – Calapooia

Spring chinook surveys were conducted in 2002 and 2003, with the finding of 16 redds in 2002 and 2 redds in 2003 (Schroeder et al. 2005). In 2003, about 200 adult hatchery origin spring chinook were released into the Calapooia (Schroeder et al. 2003). These hatchery fish are likely responsible for producing the 2 redds observed. Of 48 carcasses surveyed in 2003, 43 (90%) were fin clipped as hatchery fish; the origin of the other 5 fish was unknown, as not all hatchery origin fish are clearly fin clipped (Schroeder et al. 2003). A survey of 27 female carcasses in the Calapooia in 2003 found 100% pre-spawning mortality (Schroeder and Kenaston 2004). The data indicate there is little or no natural production of spring chinook in the Calapooia and we considered the population to be extirpated or nearly so. The Oregon Native Fish Status report (ODFW 2005) listed the Calapooia spring chinook population as a "fail" for abundance and a "fail" for productivity.

A&P – McKenzie

A time series of abundance sufficient for quantitative analysis is available for the Clackamas spring run population (Appendix B). Descriptive graphs and viability analysis results are provided in Figure 20 to Figure 26 and in Table 7 to Table 10. The population long-term geometric mean natural origin spawners is relatively high (>1,500), which is in the very low risk minimum abundance threshold category (**Error! Reference source not found.**). The proportion of hatchery fish in recent years has averaged 35%, making it difficult to obtain a precise estimate of population productivity for wild fish. The pre-harvest viability curve analysis suggests that the population is most likely in the high to moderate risk category. The CAPM and PopCycle modeling suggests that the population is most likely in the moderate risk category, with a CRT risk estimates of 11% and 8% in 100 years, respectively. The escapement viability curve suggests that a population experiencing the pattern of harvest that occurred over the available time series (average mortality rate = 0.44) would be in high or very high risk category. There is considerable uncertainty about the level of pre-spawning mortality in the basin, but it may be significant (Figure 27). The Oregon Native Fish Status report (ODFW 2005) listed the North Santiam spring chinook population as a "pass" for abundance and a "pass" for productivity.

Taken together, the data suggest that with respect to the A&P criterion the most probable classification for this population is the moderate extinction risk category. However, given the uncertainty associated with the analysis, there is a small possibility that the risk classification could be very high or very low.
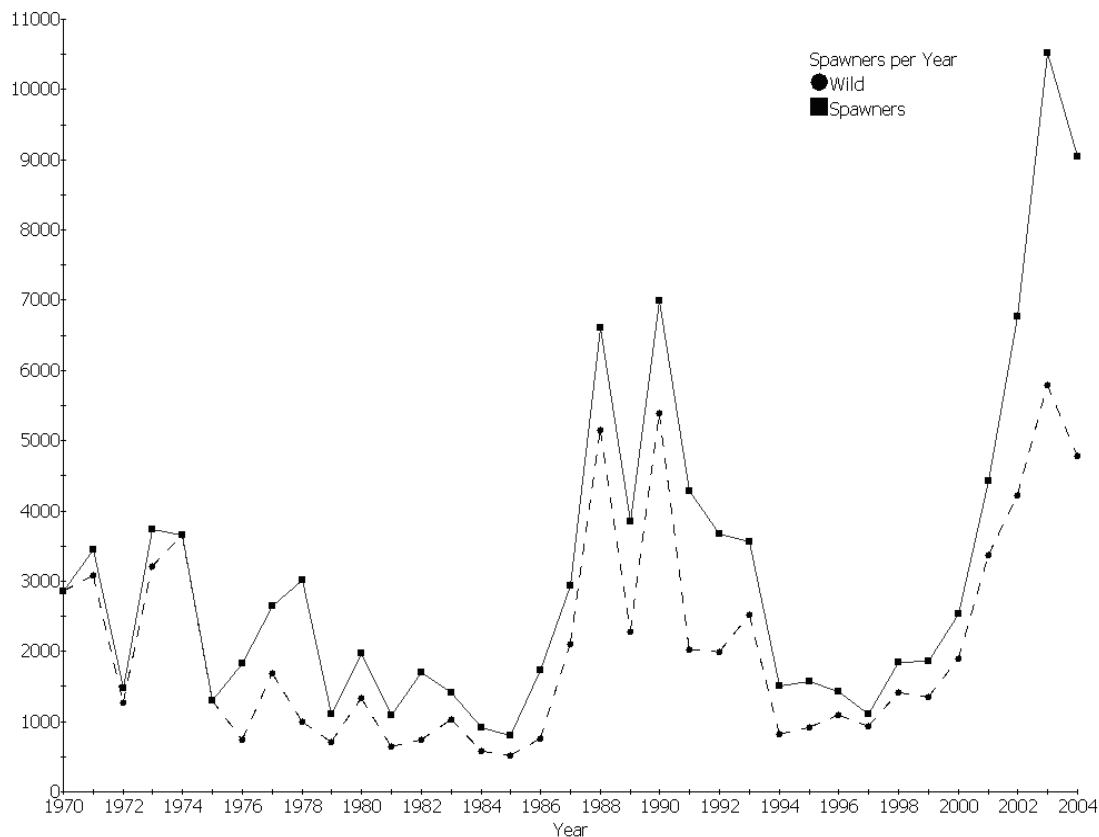
Figure 20: McKenzie spring chinook abundance.
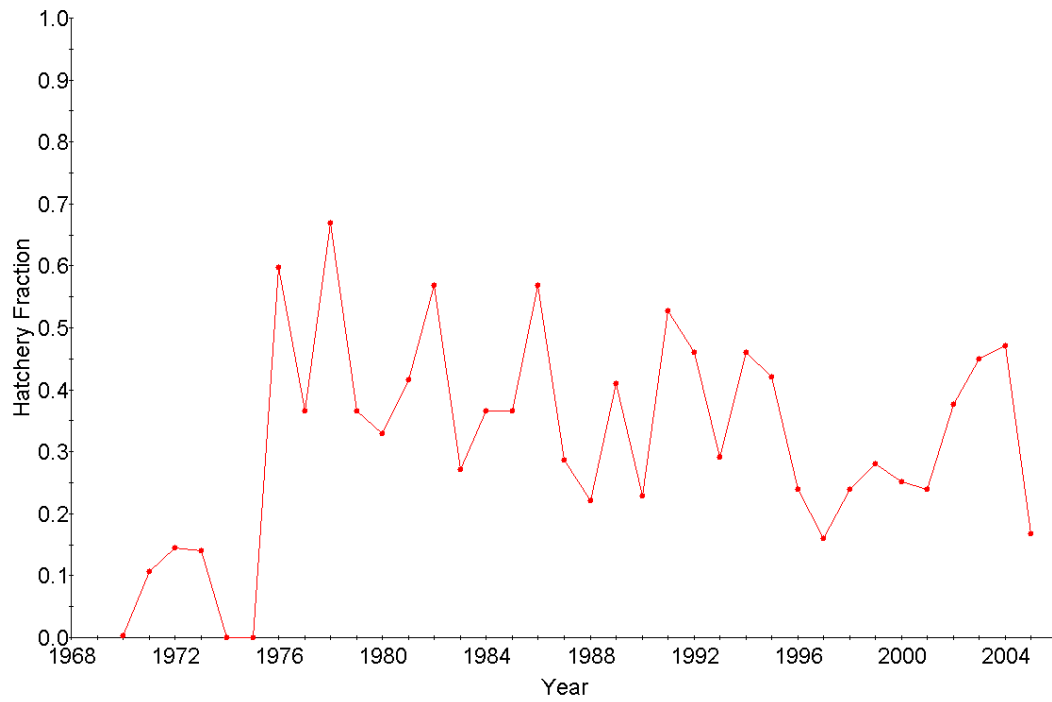
Figure 21: McKenzie spring chinook hatchery fraction.
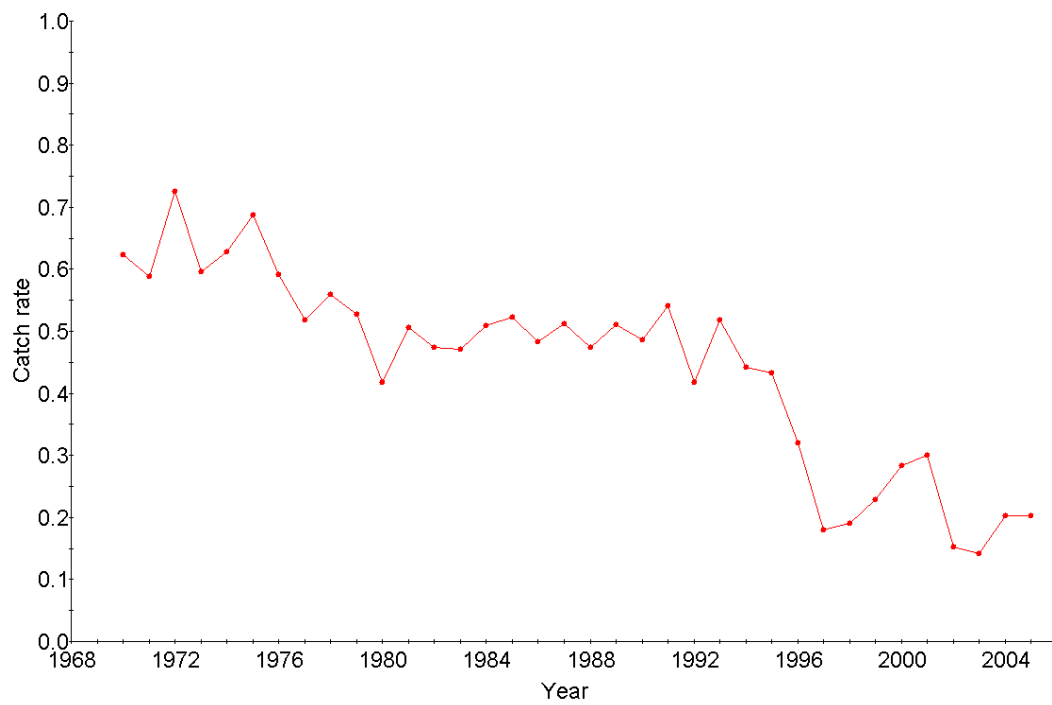
Figure 22: McKenzie spring chinook harvest rate
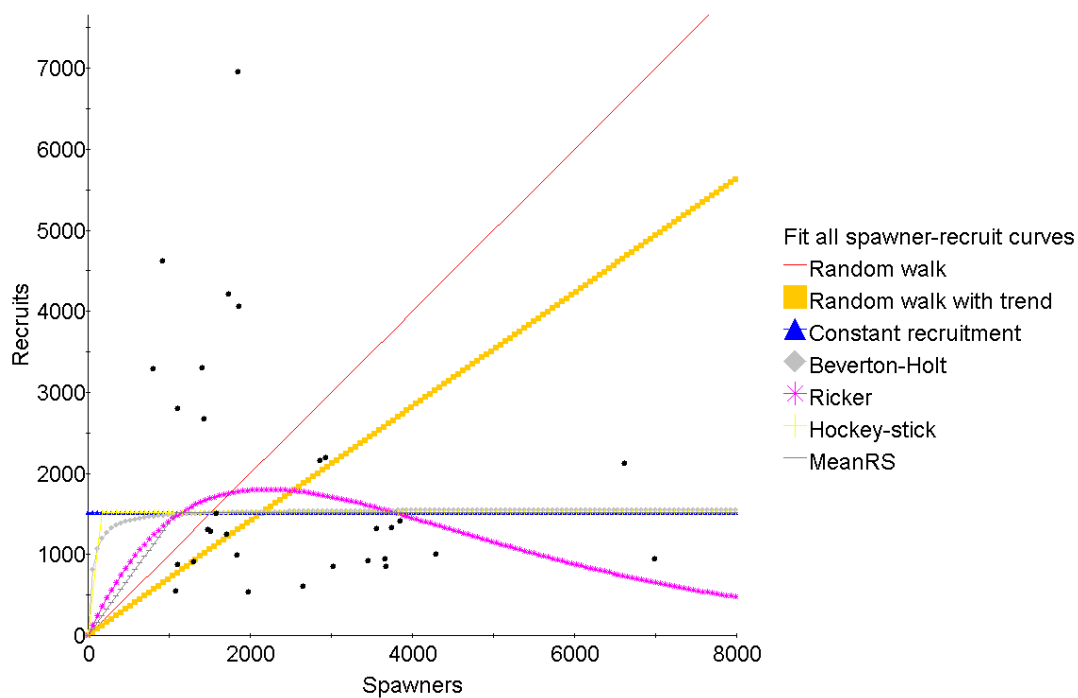
Figure 23: McKenzie spring chinook escapement recruitment functions.
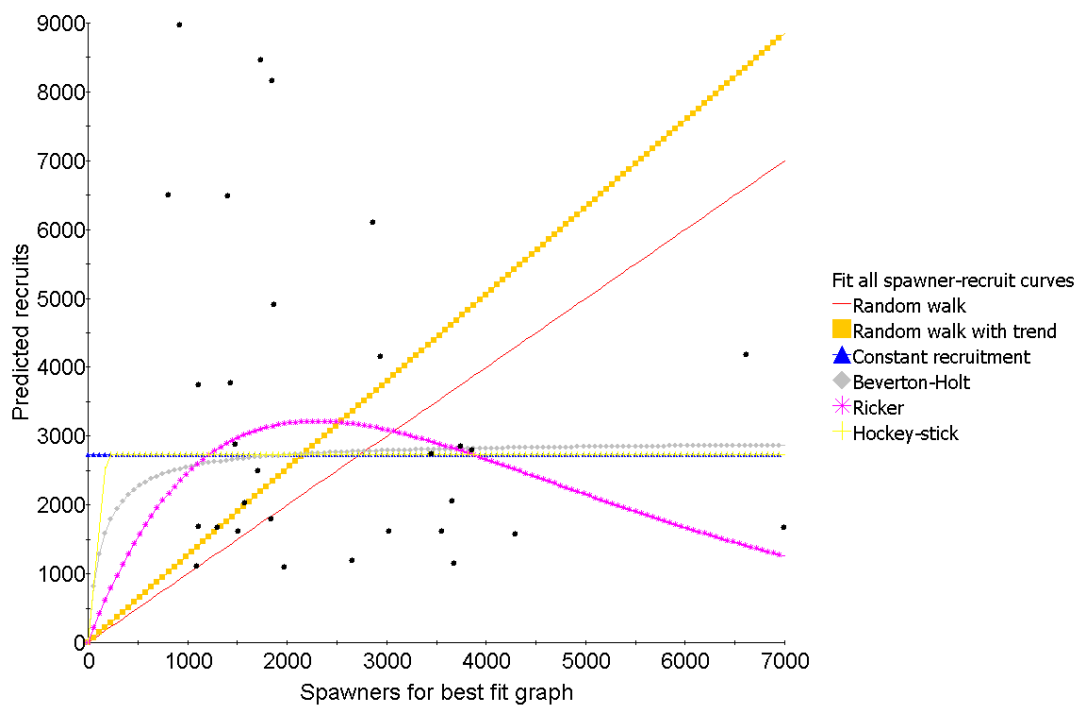
Figure 24: McKenzie spring chinook pre-harvest recruitment functions.
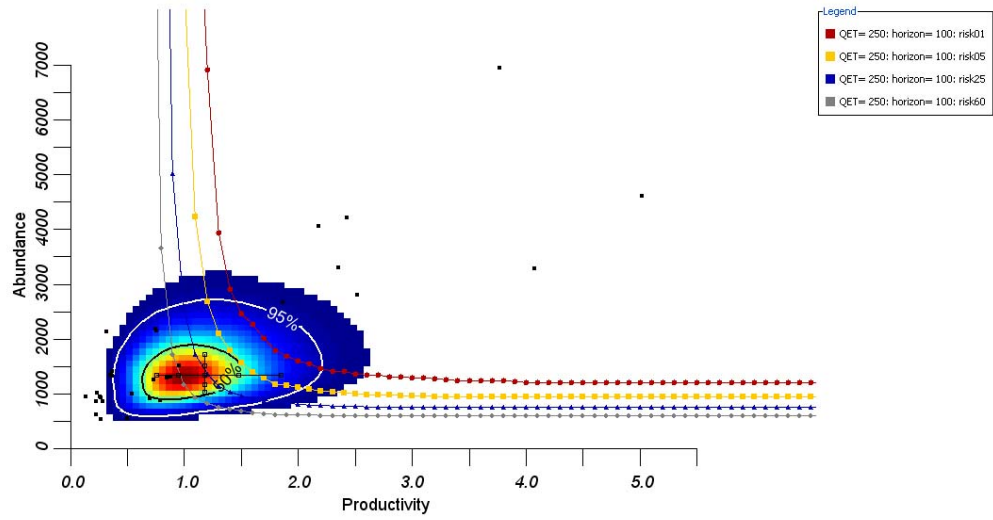
Figure 25: McKenzie spring chinook escapement viability curve.
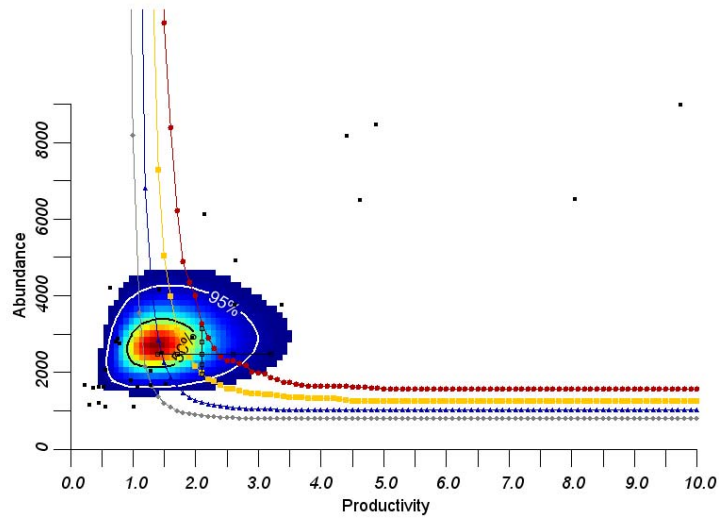
Figure 26: McKenzie spring chinook pre-harvest viability curve.

Figure 19. Pre-spawning mortality (%) of Chinook salmon in the McKenzie Basin estimated from recovery of female carcasses that died before spawning, and from number of successful spawners upstream of Leaburg Dam (from redd counts) to number of potential spawners (from counts of fish passing Leaburg Dam), 2001–2005. Starting dates of carcass surveys for each year are given in parentheses.
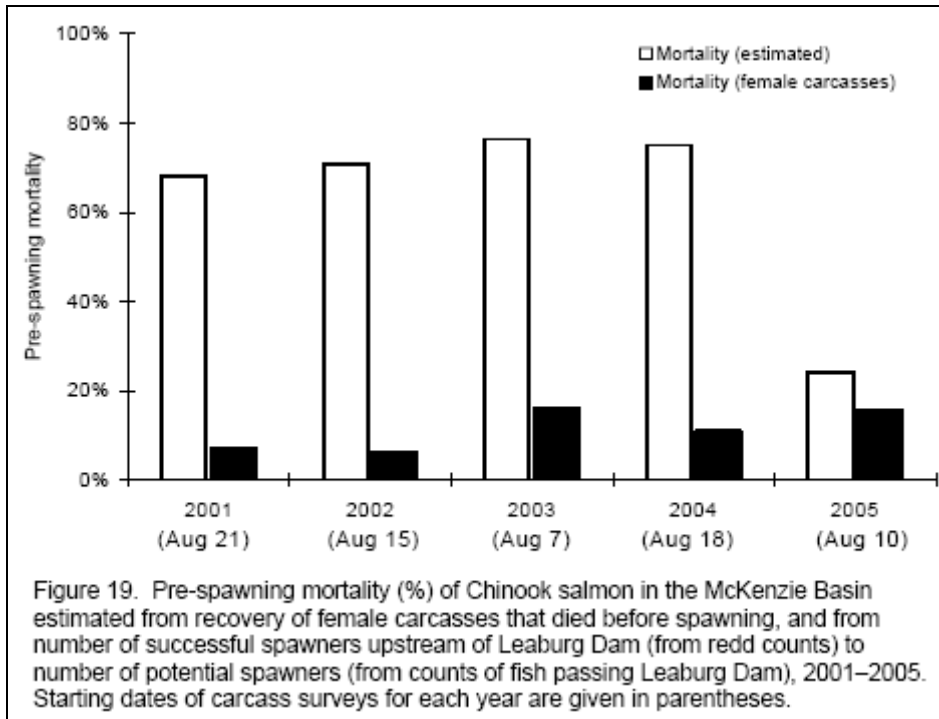
Figure 27: Estimates of pre-spawning mortality in the McKenzie River based two different methods. Copied from Schoerder et al. 2005. Schoerder et al. express more confidence in the carcass survey than the dam count method, but the exact reason for the discrepancy is unresolved.

Table 7: McKenzie spring chinook summary statistics. The 95% confidence intervals are shown in parentheses.

| Statistic	Escapement		Pre-harvest	
	Total Series	Recent Years	Total Series	Recent Years
Time Series Period	1970-2005	1990-2005	1970-2005	1990-2005
Length of Time Series	36	16	36	16
Geometric Mean Natural Origin Spawner Abundance	1655 (1305-2099)	2104 (1484-2983)	NA	NA
Geometric Mean Recruit Abundance	1521 (1182-1957)	1835 (1113-3026)	2730 (2142-3479)	2491 (1586-3912)
Lambda	0.927 (0.761-1.129)	0.944 (0.517-1.722)	1.041 (0.858-1.264)	0.992 (0.549-1.793)
Trend in Log Abundance	1.017 (0.994-1.04)	1.047 (0.972-1.126)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.705 (0.485-1.024)	0.782 (0.339-1.802)	2.223 (1.47-3.362)	1.061 (0.488-2.307)
Geometric Mean Recruits per Spawner (broods < median spawner abudance)	1.307 (0.848-2.016)	1.775 (0.969-3.25)	1.017 (0.994-1.04)	2.289 (1.283-4.082)
Average Hatchery Fraction	0.318	0.329	NA	NA
Average Harvest Rate	0.444	0.315	NA	NA
CAPM median extinction risk probability (5th and 95th percentiles in parenthesis)	NA	NA	0.125 (0.030-0.355)	NA
PopCycle extinction risk	NA	NA	0.08	NA

Table 8: Escapement recruitment parameter estimates and relative AIC values for McKenzie spring chinook. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.04 (0.88-1.36)	25.1
Random walk with trend	0.7 (0.54-1)	NA	0.98 (0.84-1.32)	23.6
Constant recruitment	NA	1521 (1255-1922)	0.66 (0.57-0.88)	0
Beverton-Holt	29.76 (5.38-28.87)	1568 (1301-2115)	0.67 (0.57-0.9)	2.4
Ricker	2.22 (1.47-3.7)	1803 (1512-2462)	0.7 (0.61-0.95)	4.9
Hockey-stick	9.3 (2.79-28.6)	1521 (1245-1915)	0.66 (0.57-0.89)	2
MeanRS	1.4 (1.02-1.95)	1521 (1247-1859)	0.49 (0.31-0.64)	13

Table 9: Pre-harvest recruitment parameter estimates and relative AIC values for McKenzie spring chinook. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.98 (0.82-1.27)	23.6
Random walk with trend	1.26 (0.96-1.78)	NA	0.95 (0.81-1.26)	23.8
Constant recruitment	NA	2733 (2262-3410)	0.64 (0.55-0.85)	0
Beverton-Holt	29.96 (7.05-29.05)	2842 (2400-3923)	0.65 (0.56-0.87)	2.7
Ricker	3.81 (2.53-6.22)	3218 (2731-4359)	0.68 (0.59-0.93)	5.6
Hockey-stick	6.24 (4-28.59)	2729 (2251-3403)	0.64 (0.54-0.85)	2
MeanRS	2.41 (1.76-3.31)	2730 (2259-3318)	0.46 (0.3-0.59)	15.5

Table 10: McKenzie spring chinook CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in 'Extirpated or nearly so' category	0.656	0.804	0.997
Probability the population is above 'Moderate risk of extinction' category	0.428	0.606	0.835
Probability the population is above 'Viable' category	0.193	0.333	0.103
Probability the population is above 'Very low risk of extinction' category	0.062	0.125	0.002

A&P – Middle Fork Willamette

Recent redd survey results for the Middle Fork Willamette River are show in Figure 28. These indicate a relatively low redd density in this population. Of the fish that return nearly all are of hatchery origin (Figure 29). In addition there is a high estimated pre-spawning mortality (Figure 30). Although the pre-spawning mortality estimates are not considered very precise, it appears that over 80% the females that return to the river die before spawning; second only to the Calapooia population for the highest spring chinook pre-spawn mortality in the Willamette. Taken together, these data indicate little, if any, natural production of spring chinook in the Middle Fork Willamette. Based on this evidence, this population under the A&P criterion is most likely at very high extinction risk. The Oregon Native Fish Status report (ODFW 2005) listed the "Upper Willamette" spring chinook population (contains the Middle Fork population plus Mosby Creek) as a "fail" for abundance and a "fail" for productivity.
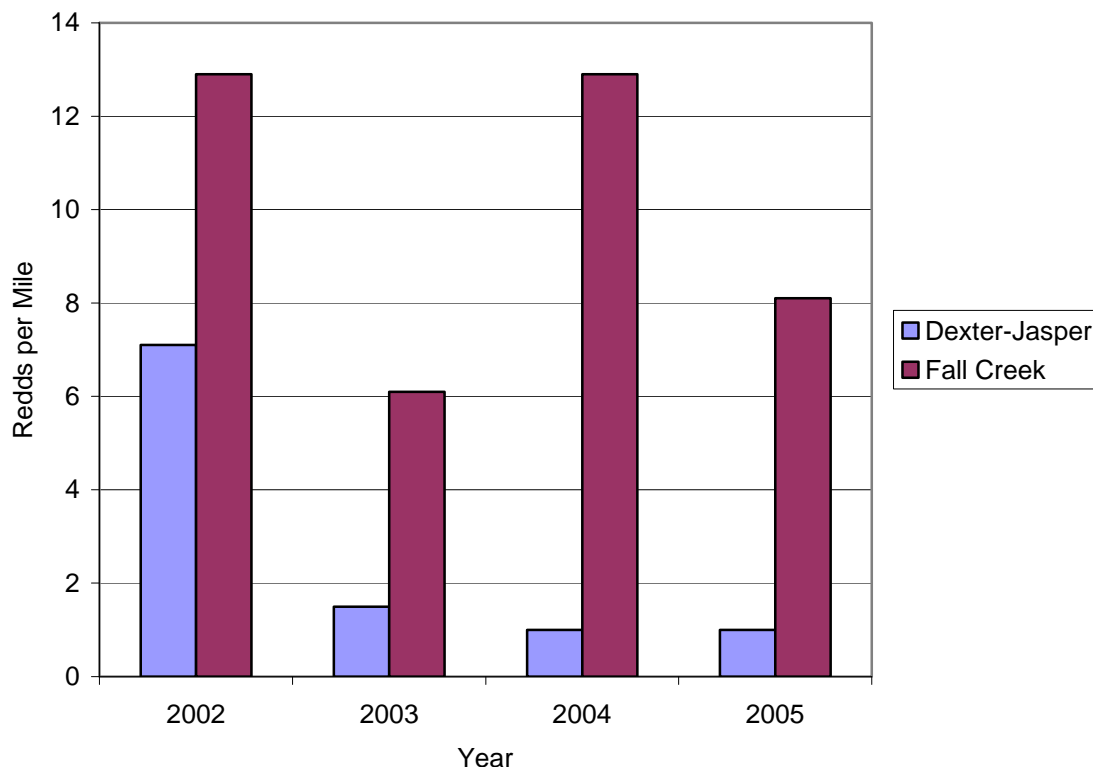
Figure 28: Redds per mile of spring chinook in sections of the Middle Fork Willamette (Schoeder et al. 2005). The Dexter-Jasper survey was 9.0 miles and the Fall Creek survey was 16 miles.
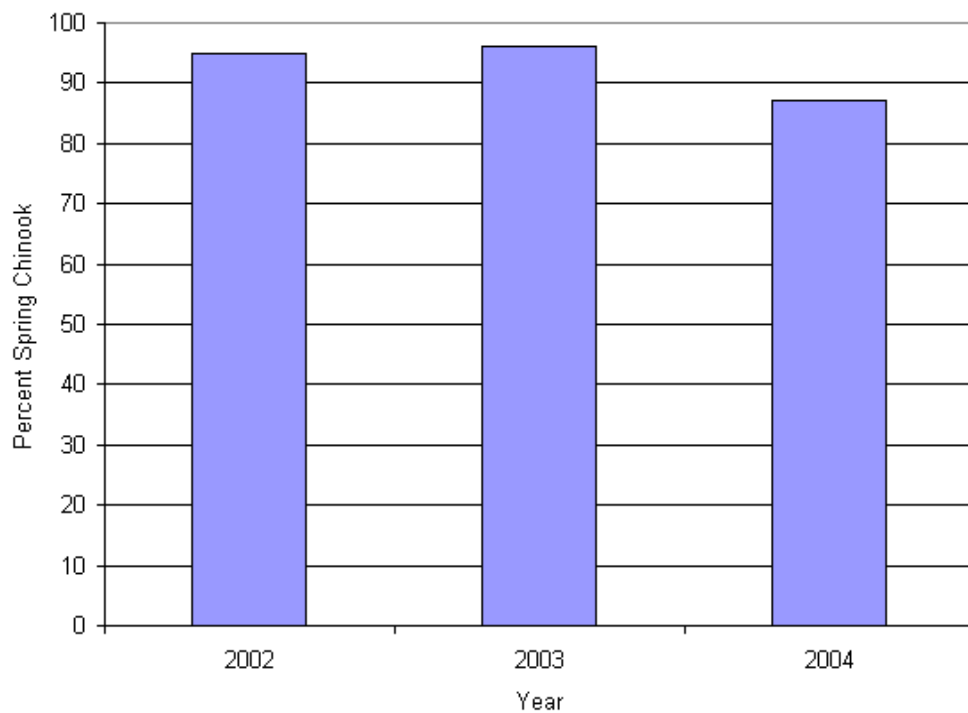
Figure 29: Percent of spring chinook spawners of hatchery origin in the Middle Fork Willamette between Dexter and Jasper and Fall Creek (Schroeder et al. 2005).
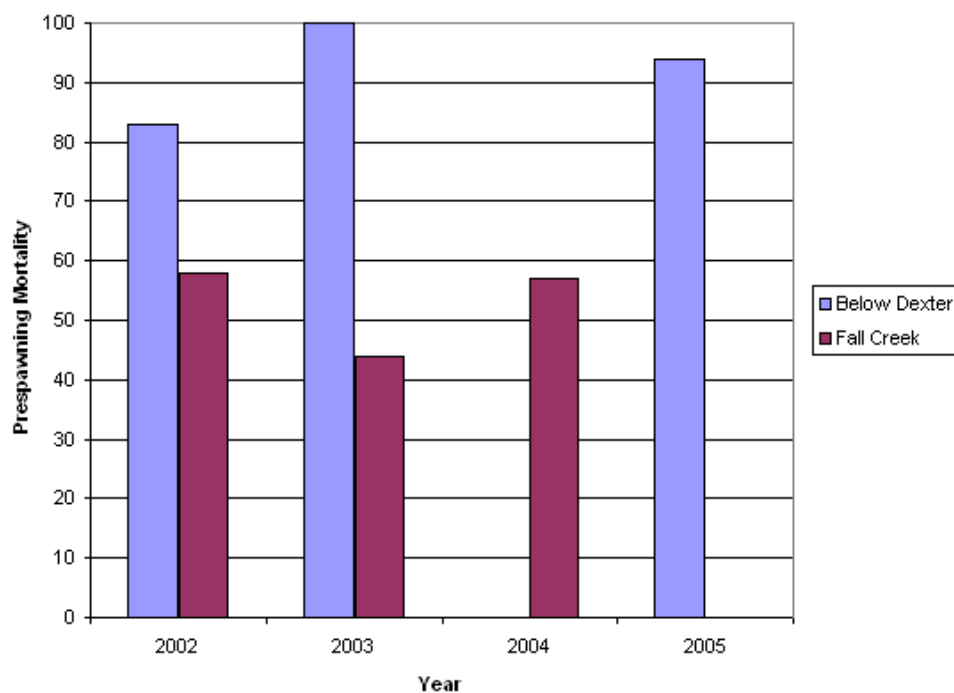
Figure 30: Pre-spawning mortality estimates for spring chinook in the Middle Fork Willamette (Schroeder et al. 2005).

A&P – Criterion Summary

The abundance and productivity status evaluation results are shown in Figure 31. The Molalla, North Santiam, South Santiam, Calapooia and Middle Fork Willamette populations are all considered at very high risk or nearly extirpated. Lengthy time series of abundance for these populations are not available, but recent survey data suggest low numbers of redds, an extremely high proportion of hatchery fish (i.e., very few wild fish) and unsustainably high pre-spawning mortality rates. Based on these findings we conclude that very little natural production is taking place for these populations. In contrast there is evidence that natural production of spring chinook is occurring for the McKenzie and Clackamas populations.

In terms of the quantitative classifications for the abundance and productivity criterion, the most probable risk category for all but two of these populations was relatively certain and very high as illustrated by the diamonds in Figure 31. The exceptions are most probable classifications of 'low risk' for the Clackamas population and 'moderate risk' McKenzie population. However, for these two populations there is considerable amount of uncertainty in these conclusions as illustrated in Figure 31 by the height of the diamond symbols. It is possible (but not probable) that the conservation risk for these populations may be very low or high. However, regardless of this uncertainty, the UW ESU as a whole most likely belongs in the high risk category for this criterion. Five of the seven populations are at very high risk and the most probable risk classifications for the remaining two are 'low' and 'moderate'.
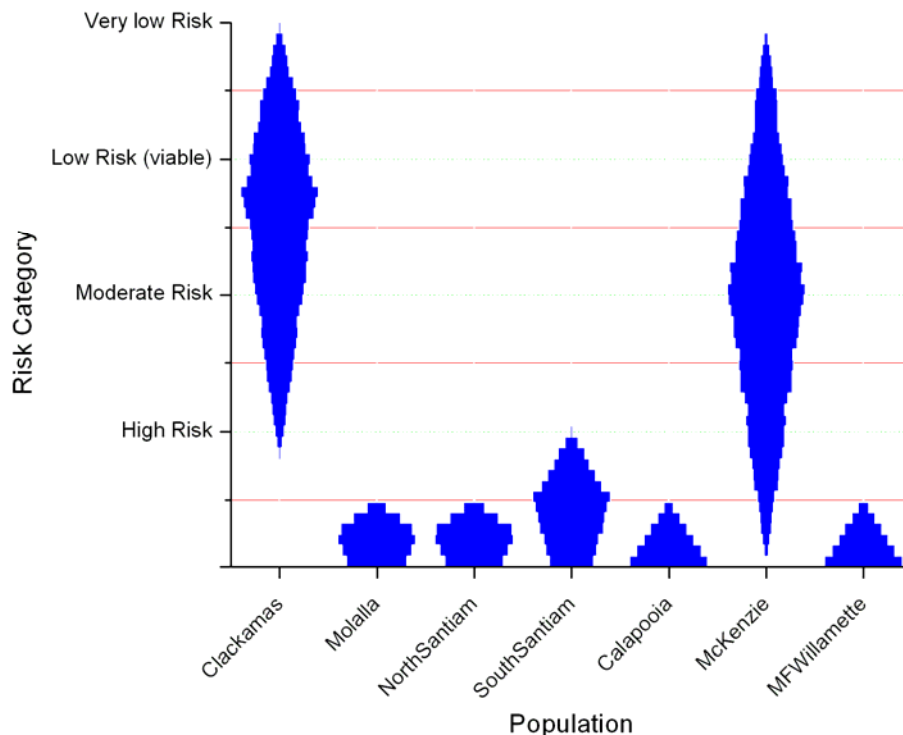
Figure 31: Upper Willamette spring chinook risk status summary based on evaluation of abundance and productivity only.

III. Spatial Structure

SS – Clackamas

Virtually the entire habitat accessible to spring chinook in the Clackamas River remains accessible today (Figure 32)(ODFW 2005). The upper Clackamas basin contains the historically-productive habitat for spring chinook and most of that habitat is of high quality today. Little spring chinook production was likely from lower basin streams where development has been extensive. A portion of the historical rearing habitat for spring chinook has been inundated by construction of three Clackamas mainstem dams – the significance of related effects on spatial diversity is unclear because reservoirs now provide significant over-winter habitat. The watershed score was reduced to address a likely loss in spatial diversity related to habitat declines in lower Clackamas, Willamette and Columbia mainstems and the estuary which may have affected the fall migrant life history pattern of this species.
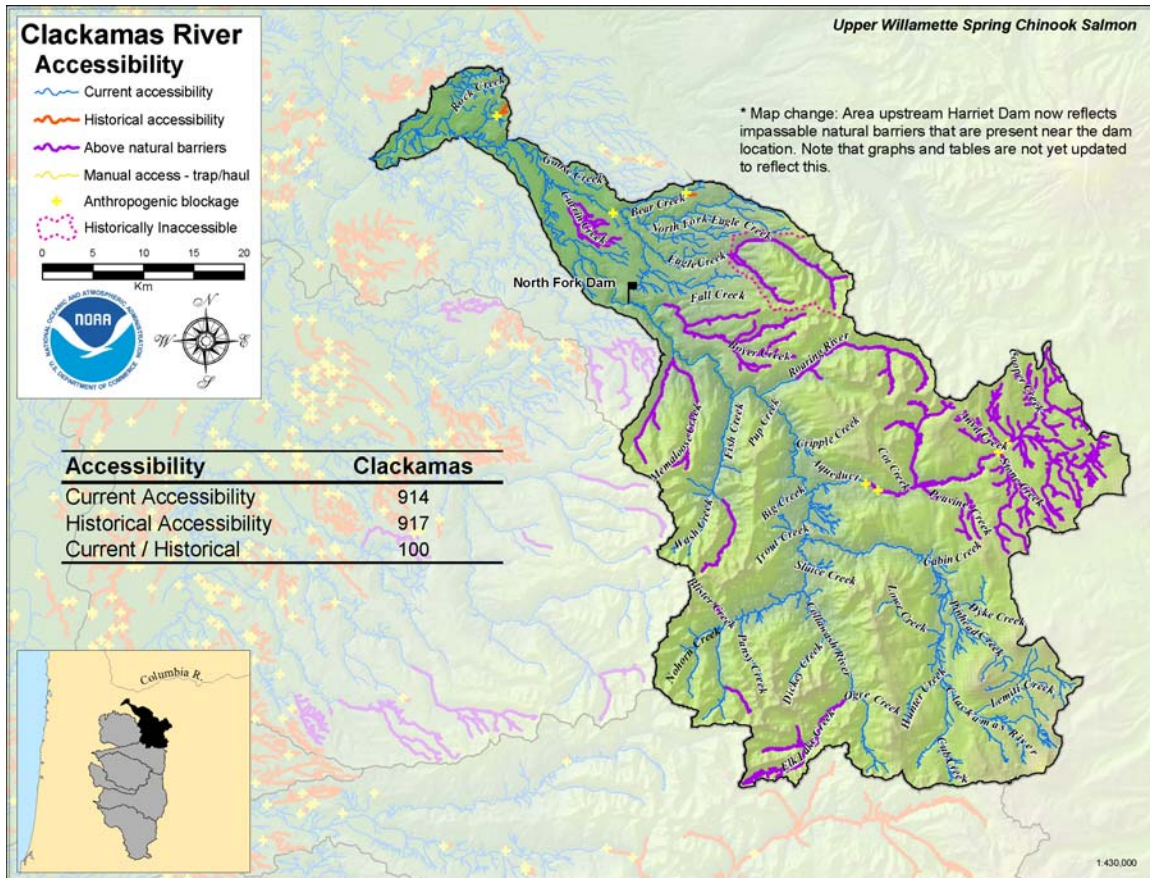
Figure 32: Clackamas River spring chinook current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Molalla

Land use and road building has limited access of anadromous fish to many higher order tributaries in the Molalla system but no large mainstem fish barriers are present. On a stream mile basis this impairment is significant (Figure 33). However, historical spring chinook spawning and rearing areas were limited to mainstem areas that remain over 95% accessible (ODFW 2005). Habitat degradation due to land use has reduced water quality and the availability of suitable spawning habitat for spring chinook in the Molalla River. The combined effects of high accessibility in historically suitable habitats and habitat quality degradation in the sub-basin and downstream, result in a modified risk score.

Figure 33: Molalla River spring chinook current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – North Santiam

Access to large portions of the historically productive spring chinook habitat has been blocked by the Detroit Reservoir (Figure 34). ODFW estimates that 42% of the historically-suitable for spring chinook is now inaccessible (ODFW 2005). Historically this area was the primary spring chinook production area for the North Santiam because the habitat is of such high quality. Much of the remaining accessible habitat is not well suited for spring chinook although some favorable reaches may still be found in the Little North Santiam River.

Figure 34: North Santiam River spring chinook current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* **(i.e., where fish could swim) and not necessarily habitat that fish would use.**

SS – South Santiam

Access to large portions of the historically-productive spring chinook habitat have been blocked by Foster and Green Peter Dams, though there is currently and experimental trap and haul program at Foster Dam (Figure 35). ODFW estimates that 40% of the historically-suitable for spring chinook is now inaccessible (ODFW 2005). Like the North Santiam these blocked areas contained some of the best spring chinook habitat in the basin. ODFW (2005) estimates that historically 70% of the spring chinook production from this system originated from this now inaccessible portion of the watershed. The remaining habitat is not well suited for spring chinook. The watershed score for spatial structure was further reduced to account for relative poor habitat suitability in the remaining accessible habitat and in the Willamette and Columbia mainstems and the estuary.
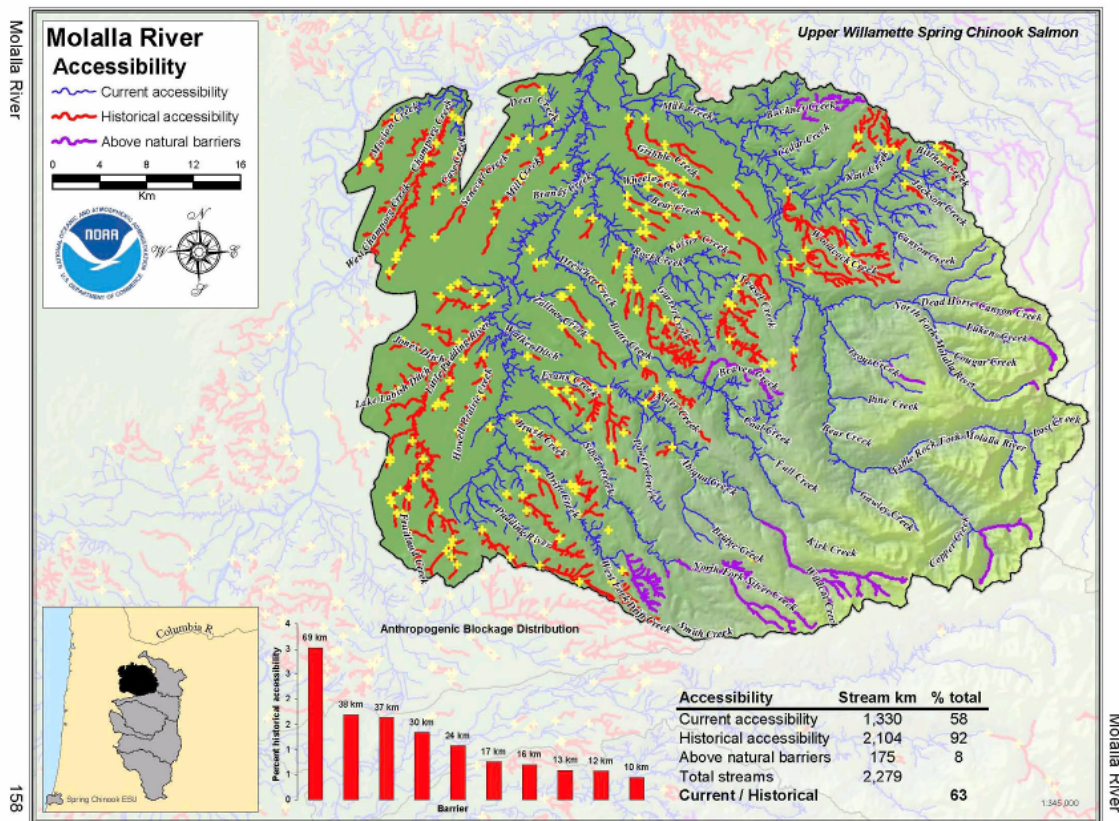

Figure 35: South Santiam River spring chinook current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Calapooia

Over half of the stream length historically accessible to spring chinook in the Calapooia is currently blocked (Figure 36). In addition, habitat degradation has substantially reduced the quality of remaining accessible habitat, making spatial structure a substantial source of risk in the Calapooia.
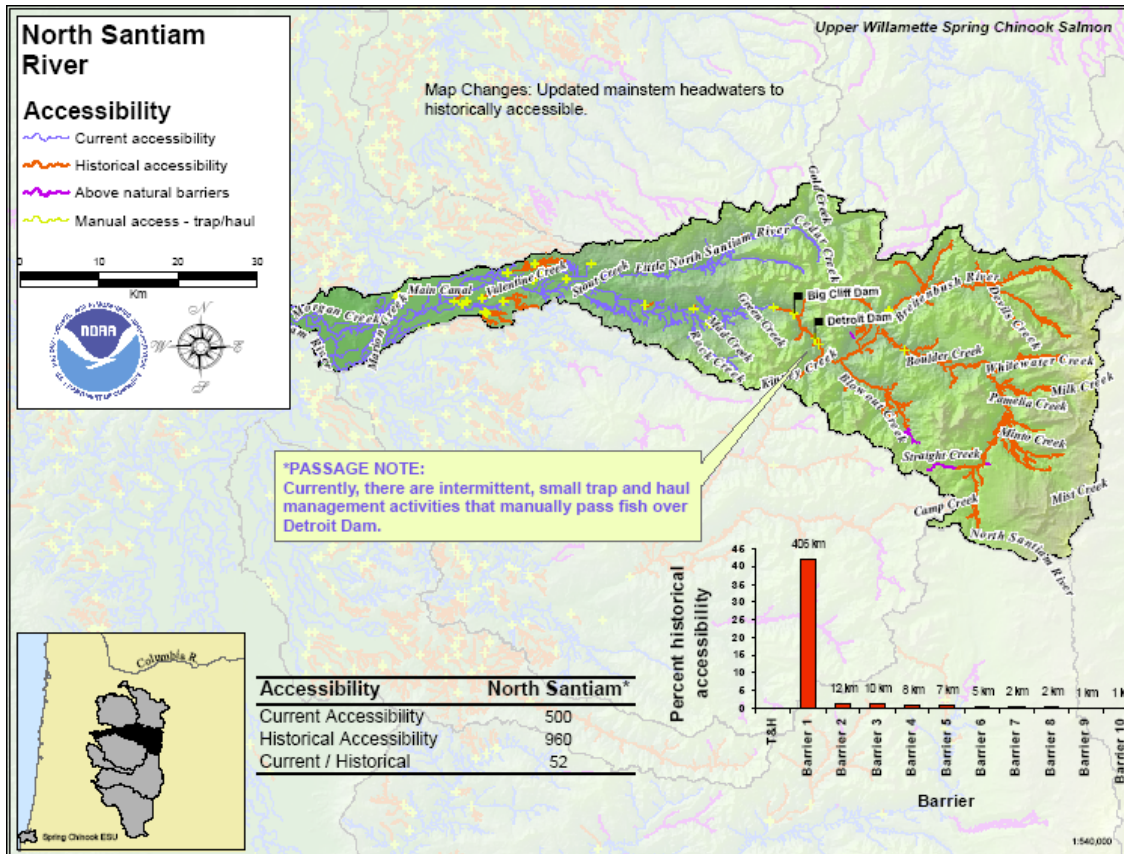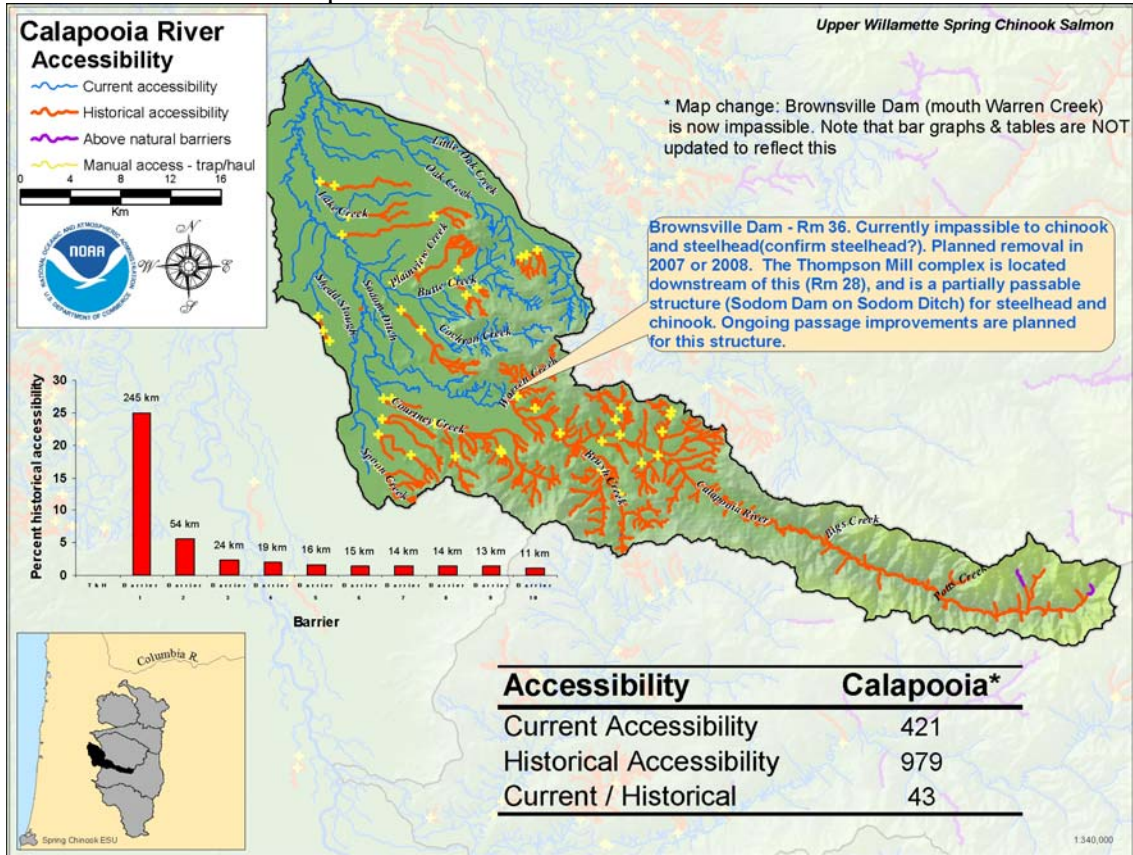

Figure 36: Calapooia River spring chinook current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use. (NOTE: The Brownsville Dam is not considered a barrier for steelhead.)

SS – McKenzie

Most of the historical spring chinook habitat in the McKenzie River remains accessible today (Figure 37) and this system supports the largest extant spring chinook population upstream of Willamette Falls (ODFW 2005). Historical habitats have been blocked on McKenzie River tributaries by the Cougar and Blue River dams. ODFW (2005) estimates that 16% of the historical habitat has been blocked on a stream mile basis and the accessibility analysis including higher order streams estimates a 25% loss (Maher et al. 2005). High quality habitats remain accessible in other parts of the system. The watershed score for spatial structure was reduced to account for losses in historically-significant rearing habitat in the upper Willamette mainstem.
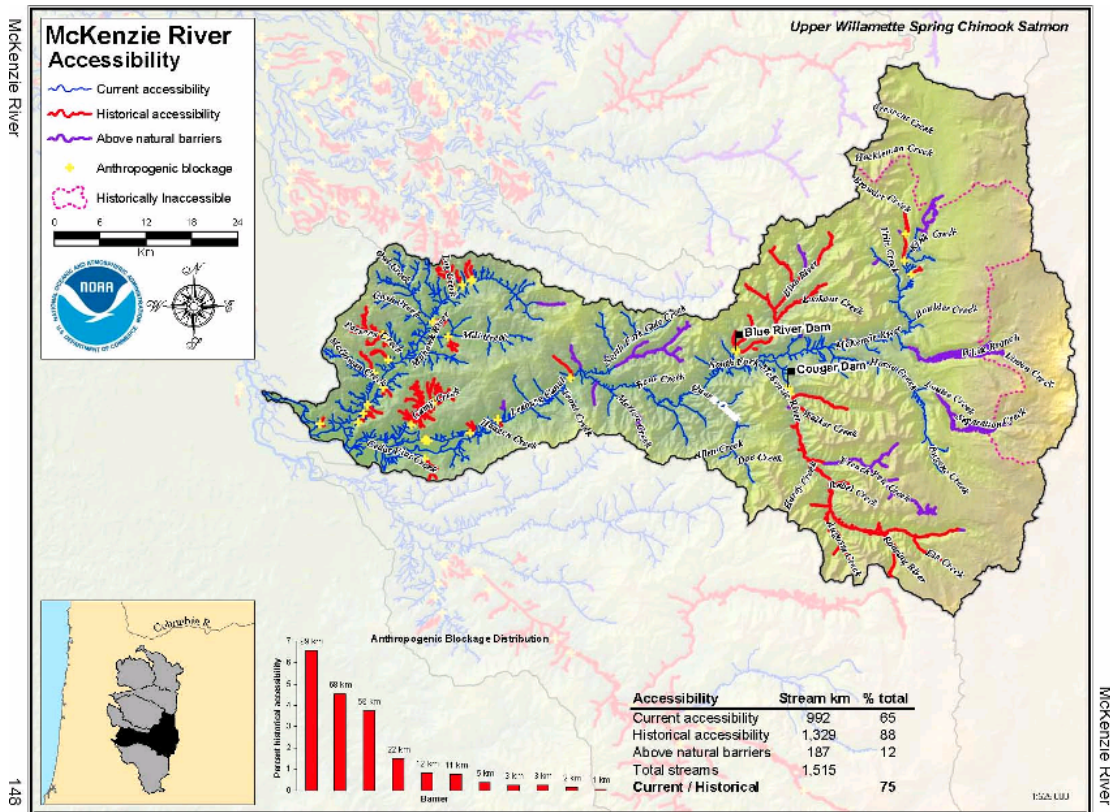
Figure 37: McKenzie River spring chinook current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Middle Fork Willamette

The majority of the historical spring chinook habitat in the Middle Fork Willamette has been blocked by dams (Figure 38). ODFW (2005) estimates that 57% of the historical habitat is no longer accessible, and that this habitat accounted for an even greater portion of the historical production. The remaining accessible habitats are not well suited to spring chinook production.

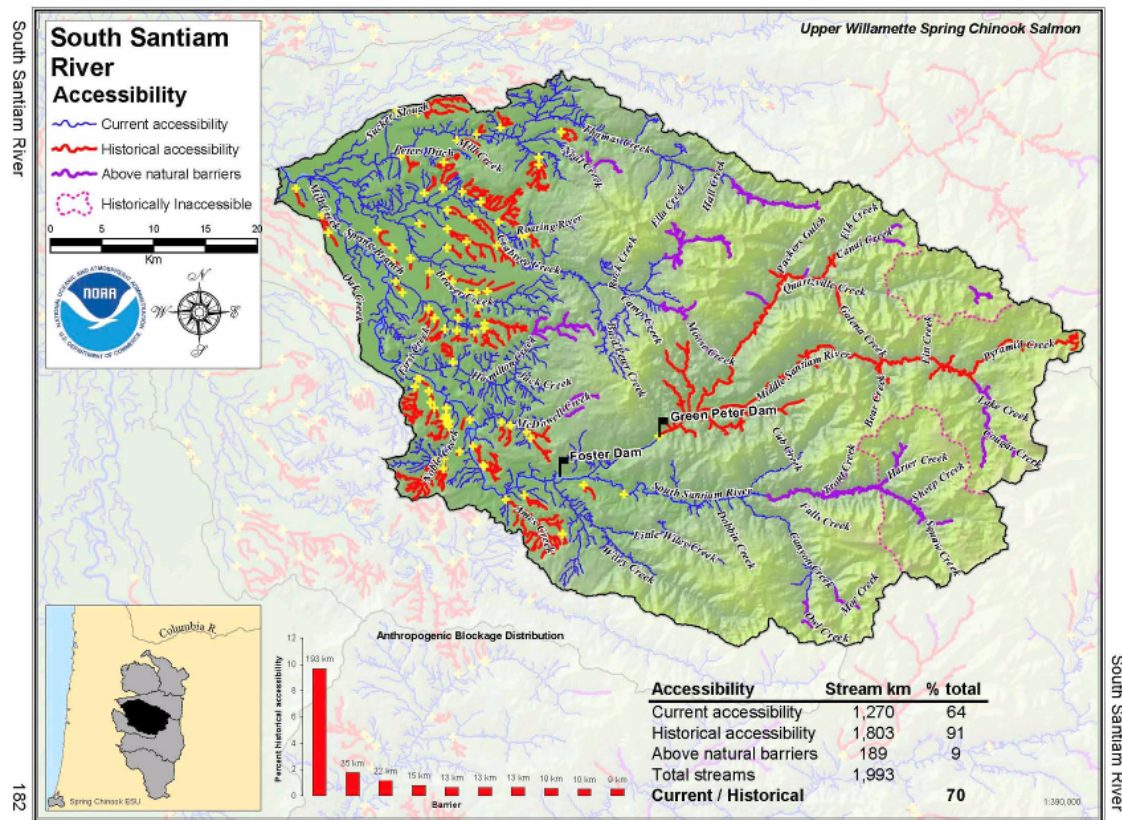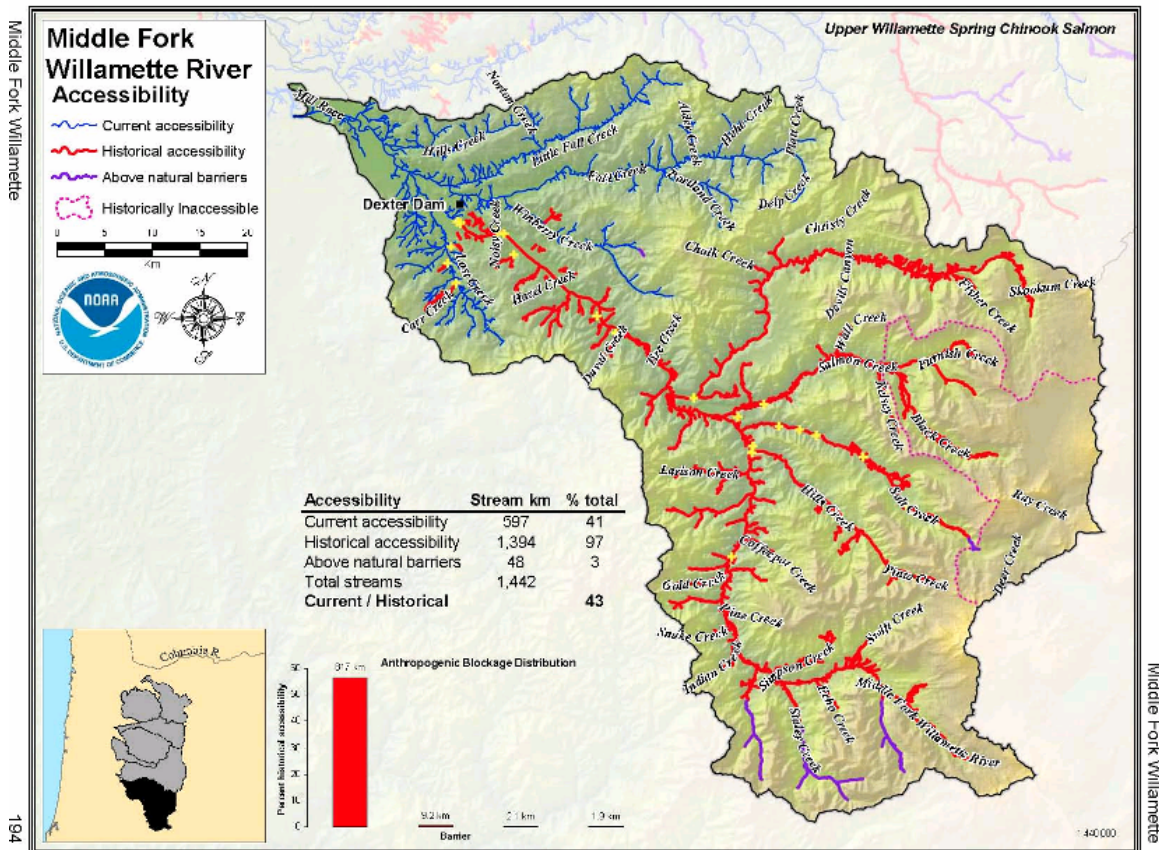**Figure 38: Middle Fork Willamette River spring chinook current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Part 1), these maps depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.**

SS – Criterion Summary

Except for the Clackamas population, the percentage of historically accessible habitat lost due to human activities (primarily dam construction) exceeds 25% for each population within this ESU (Figure 39). In the case of populations in the North Santiam Calapooia and Middle Fork Willamette, habitat loss has been particularly high (around 50%).

SS scores for each population were adjusted, where applicable, on the basis of two factors: 1) the suitability/quality of the blocked habitat with respect to chinook production and 2) the degree to which the remaining accessible habitat has been degraded from historical conditions. The adjustments and final SS scores for each population are presented in Table 11. For the SS criterion the most probable risk category for a majority of the populations was 'high' or 'very high' as evidenced by the SS rating in Table 11 and illustrated by the placement of the widest portion of the diamonds in Figure 40. The remaining three populations have a most probable risk classification of 'low' risk. However, when the uncertainty associated with these rating is considered, only one population (Clackamas) is clearly in the 'low' risk category. The other two populations (Molalla and McKenzie) the three populations may in fact belong in the 'moderate' risk category. Given the wide range among the populations in terms of scores for this criterion, it is difficult to draw conclusions as to an overall ESU rating. However, we conclude the most probable ESU risk classification for the SS criterion would be 'high'.
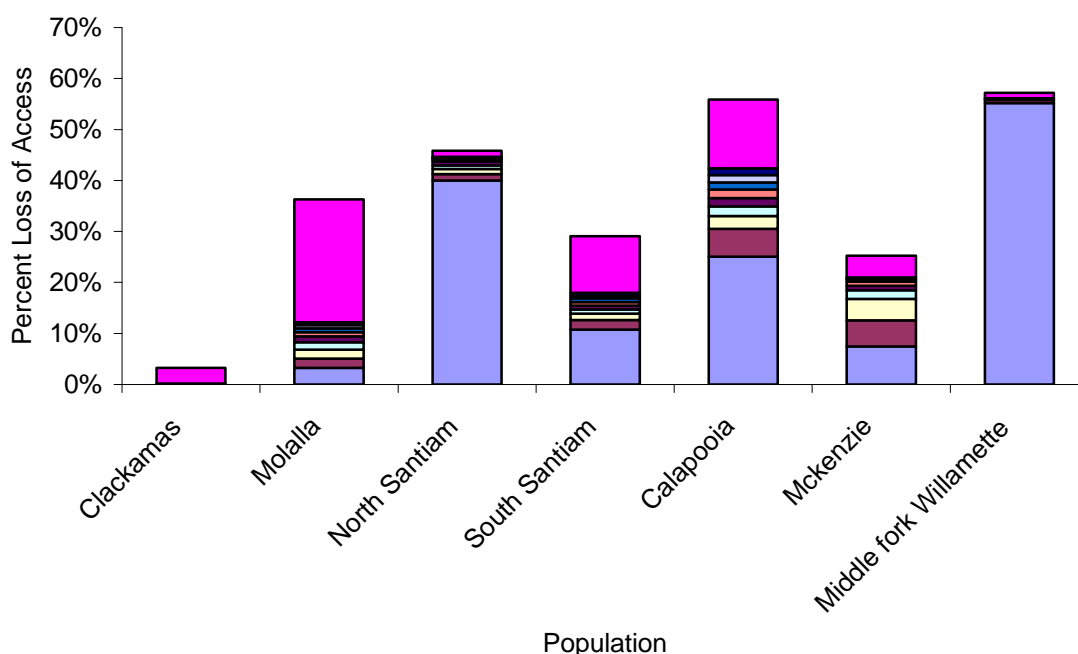
Figure 39: Percent loss in Upper Willamette spring chinook accessibility due to anthropogenic blockages (based on Maher et al. 2005). Each color represents a blockage ordered from largest to smallest (bottom-up). The top most blockages, for example the pink segment of the Calapooia bar are a collection of many smaller blockages. Note that the pool of smaller blockages can be greater than larger single blockages. These percentages are based on current (2007) accessibility estimates and may differ from the access maps above as described in the map figure legends.

Table 11: Spatial structure persistence category scores for UW chinook populations.

Population	Base Access Score	Adjustment for Large Single Blockage	Adjusted Access Score	SS Rating Considering: Access Score, Historical Use Distribution, and Habitat Degradation	Confidence in SS rating
Clackamas	4	no	4	3.5	M
Molalla	2	no	2	2.5	L
North Santiam	1	yes	0.5	0.5	H
South Santiam	2	no	2	1	M
Calapooia	1	yes	0.5	0.5	M
McKenzie	3	no	3	2.5	M
Middle Fork Willamette	1	yes	0.5	0.5	M
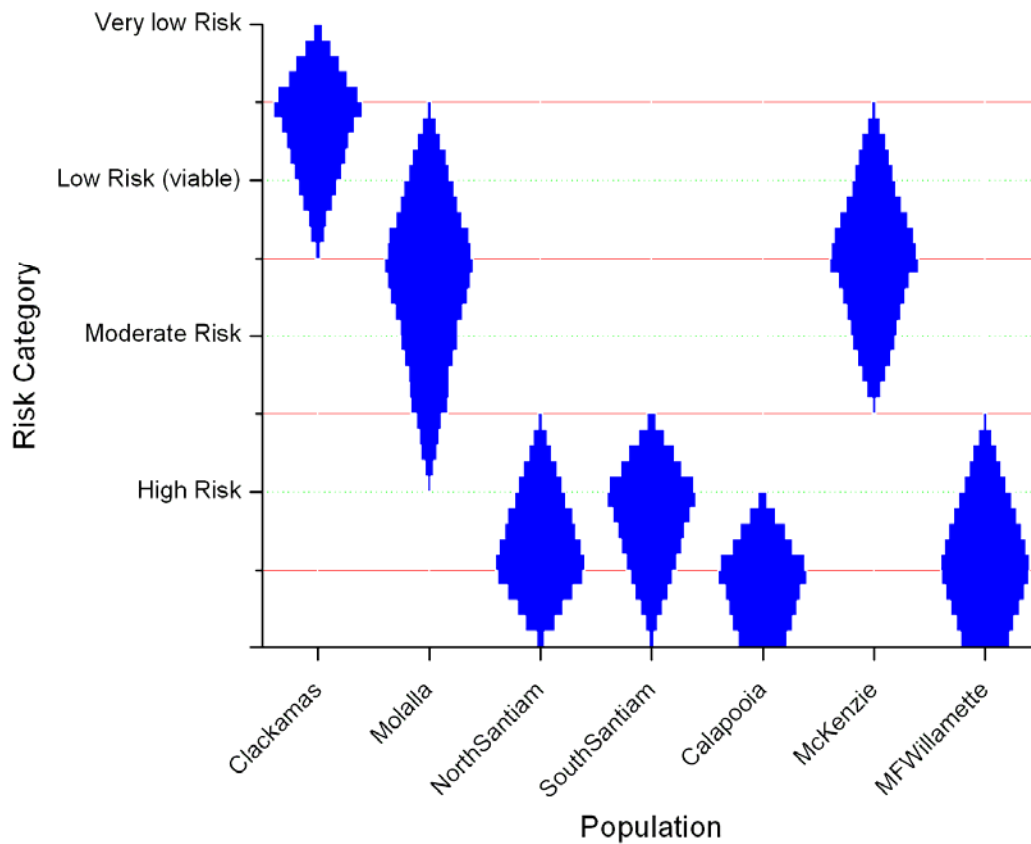
Figure 40: Upper Willamette spring chinook risk status summary based on evaluation of spatial structure only.

IV. Diversity

DV – Background and Overview

Historically, the Willamette River Basin provided sufficient spawning and rearing habitat for large numbers of spring-run chinook salmon. The predominant tributaries to the Willamette River that historically supported spring-run chinook salmon include the Molalla (RKm 58), Calapooia (RKm 192), Santiam (RKm 174), McKenzie (RKm 282), and Middle Fork Willamette Rivers (RKm 301)—all drain the Cascade Range to the east (Mattson 1948, Nicholas 1995). There are no direct estimates of the size of the chinook salmon runs in the Willamette River Basin prior to the 1940s (Table 8). Wilkes (1845) estimated that the fishery at Willamette Falls could yield up to 800 barrels (122,000 kg) of salmon. Collins (1892) reported that 16,874 salmon (303,732 kg) were shipped to Portland from the Willamette Falls fishery in April and May 1889. This estimate would not include tribal harvest or harvest that was shipped to markets other than Portland. McKernan and Mattson (1950) presented anecdotal information that the Native American fishery at Willamette Falls may have yielded 908,000 kg of salmon (454,000 fish @ 9.08 kg). Mattson (1948) estimated that the spring chinook salmon run in the 1920s may have been five times the existing run size of 55,000 fish (in 1947) or 275,000 fish, based on egg collections at salmon hatcheries. In general, it is likely that the Willamette River Basin historically supported a run of several hundred thousand fish.

Prior to the laddering of Willamette Falls, passage by returning adult salmonids (RKm 37) was only possible during the winter and spring high-flow periods. The early run timing of Willamette River spring-run chinook salmon relative to other Lower Columbia River spring-run populations is viewed as an adaptation to flow conditions at Willamette Falls. chinook salmon begin appearing in the Lower Willamette River in February, but the majority of the run ascends Willamette Falls in April and May, with a peak in mid May. Wilkes (1845) reported that the salmon run over the falls peaked in late May. Low flows during the summer and autumn months prevented fall-run salmon from accessing the Upper Willamette River Basin. Since the Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), the reproductive isolation provided by the falls probably has been uninterrupted for a considerable time period. Willamette Falls may have been formed by the receding floodwaters of the Bretz Floods (12,000–15,000 years before present) (Nigro 2001). This isolation has provided the potential for significant local adaptation relative to other Columbia River population.

DV – Clackamas River Spring-Run Chinook Salmon

Life History Traits – Barin (1886) observed a run of chinook salmon that "commences in March or April, sometimes even in February." Additionally, from 1890 to 1903 spring run fish were spawned at the Clackamas Hatchery from mid-July to late August (Willis et al. 1995). Currently, the majority of spawning takes place from September through early October (Willis et al. 1995). Clackamas River spring-run chinook mature primarily at 4 years old (62% of the run) and at 5 years old (35% of the run) (Howell et al. 1985). Score = 2.

Effective Population Size – Historically, the Clackamas River supported a large population of spring-run chinook salmon; however, the construction of the Cazadero Dam in 1904 (RKm 43) and River Mill Dam in 1911 (RKm 37) limited migratory access to the majority of the historical spawning habitat for the spring run. In 1917, the fish ladder at Cazadero Dam was destroyed by floodwaters, eliminating fish passage to the upper basin (ODFW 1992). The average annual dam count (River Mill or North Fork Dam) from 1952-59 was 461 (Murtagh et al. 1992). Adult counts over North Fork Dam rose from 592 in 1979 to 2,122 in 1980 (Murtagh et al. 1992). Passage over North Fork Dam has averaged over 2,000 fish annually over the last 30 years. Additionally, several thousand spring-run chinook return to the Clackamas Hatchery each year. Score = 2.

Hatchery Impacts

> *Hatchery Domestication* – Hatchery production of spring-run chinook salmon in the basin continued using broodstock captured at the Cazadero and River Mill Dams (Willis et al. 1995). Transfers of Upper Willamette River hatchery stocks (primarily the McKenzie River Hatchery) began in 1913, and between 1913 and 1959 over 21.3 million eggs were transferred to the Clackamas River Basin (Wallis 1961, 1962, 1963). Furthermore, a large proportion of the transfers occurred during the late 1920s and early 1930s to supplement the failure of the runs in the Clackamas River Basin at that time (Leach 1932). In 1942 spring-run chinook salmon propagation programs in the Clackamas River Basin were discontinued.

> Artificial propagation activities were restarted in 1956 using eggs from a number of upper Willamette River hatchery stocks. The program released approximately 600,000 smolts annually through 1985. In 1976, the ODFW Clackamas Hatchery (located below River Mill Dam) began releasing spring-run chinook salmon (Willamette River hatchery broodstocks were used, since it was believed that the returns from the local population was too small to meet the needs of the hatchery (Murtagh et al. 1992)). Increases in adult returns over the North Fork Dam, and increases in redd counts above the North Fork Reservoir corresponded to the initial return of adults to the hatchery in 1980 (ODFW 1992, Willis et al. 1995). The Clackamas Hatchery predominately uses fish returning to the hatchery rack. Recent changes management policy by ODFW include releasing hatchery fish farther downstream and mass marking all hatchery releases to allow the removal of hatchery fish ascending the North Fork Dam. Prior to mass marking, it was estimated that over 75% of the fish spawning above the North Fork Dam were hatchery origin. Despite passing only unclipped fish in 2002 and 2003, studies have found that 24-30% of the spawners above North Fork Dam were hatchery-origin fish (Goodson 2005).

Genetic analysis by NMFS of naturally produced fish from the upper Clackamas River indicated that this stock was similar to hatchery stocks from the Upper Willamette River Basin (Myers et al. 1998, see Appendix A). This finding agrees with an earlier comparison of naturally produced fish from the Collawash River (a tributary to the upper Clackamas River) and upper Willamette River hatchery stocks (Schreck et al. 1986). This strongly suggests that fish introduced from the upper Willamette River have significantly interbreed into, if not overwhelmed, spring-run fish native to the Clackamas River Basin, and obscured any genetic differences that exist prior to hatchery transfers.

PNI ≤ 0.10 , Fitness = 0.65. (This scoring is problematical – issues include whether to consider the Upper Willamette origin of this broodstock as an introduction from out of basin. Also, the stock being introduced had already been used in other hatcheries for many generations.) Score = 1.5.

Hatchery Introgression – There is some uncertainty regarding the historical relationship between the spring-run chinook salmon above Willamette Falls and those in the Clackamas River. It is not clear if the genetic and phenotypic similarity between populations in the Upper Willamette River and Clackamas River is the result of massive hatchery transfers or a historical relationship. Score = NA.

Synthetic Approach – The hatchery propagation of Clackamas River chinook salmon began in the 1800s with the construction of the first hatchery in the Columbia River Basin. In recent years, hatchery operations have been marked by the importation of millions of spring-run chinook salmon eggs from the upper tributaries of the Willamette River, (above Willamette Falls). Estimates of hatchery contribution to the spawning escapement (base on passage at North Fork Dam) have historically been well above 75%, but currently between 30-50% (Goodson et al. 2005). Juveniles released into the Clackamas River have come from local adult hatchery returns and importation from other Upper Willamette River hatcheries. Genetic similarity is considered to be low, based on the lack of inclusion of "wild" (unmarked) spawners and imported eggs from outside of the basin. Diversity persistence score = 1.0.

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = 2-3**.**

Habitat Diversity – Changes to the distribution of gradients and river size has been relatively minor, although this does not consider changes in habitat quality, especially in the lower Clackamas River. Score (Order/Elevation) = 3/3.

Overall Score = 2.0. Direct changes in life history and hatchery effects were the primary concerns for this population, although many effects (especially habitat degradation) could not be accurately measured, but may also be important.

Previously: 2004 TRT 1.31, 2004 ODFW fail, 4-5 of the criteria met.

DV – Molalla River Spring-Run Chinook Salmon

Life History Traits – Craig and Townsend (1946) collected a number of subyearling juveniles moving downstream from the Molalla River. Score = NA

Effective Population Size – The Molalla River is located just above Willamette Falls and 50 Km from the mouth of the Willamette River. By 1903, the abundance of chinook salmon in the Molalla River had already decreased dramatically (ODF 1903). Surveys in 1940 and 1941 recorded 882 and 993 spring-run chinook salmon present, respectively (Parkhurst et al. 1950). Mattson (1948) estimated the run size to be 500 in 1947. Efforts are currently underway to reestablish natural production in the Molalla River Basin using other upper Willamette River spring-run populations, primarily North Santiam, Middle Fork, and McKenzie River hatchery stocks. Analysis of carcasses from the 2002 run indicated that only 2% (2) of the fish were naturally-produced of the 102 carcasses examined (Lindsey 2003). Natural productivity appears to be very low (Goodson 2005). Score = 1-2.

Hatchery Impacts

> *Hatchery Domestication* – There is no hatchery program in the Molalla River, although a large number of spring-run chinook salmon have been introduced from other Upper Willamette River populations. No genetic analysis is available for this population. Score = 1-2.

> *Hatchery Introgression* – Given the preponderance of non-local hatchery-origin fish in this DIP, use of this metric was considered more appropriate than using the PNI. The diversity score was adjusted to reflect the fact that hatchery introductions have come from the same stratum. Score = 1-2.

> *Synthetic Approach* – There is no hatchery program in the Molalla River Basin; however, a large number of Upper Willamette River spring-run chinook salmon from other hatchery programs in the ESU have been released. Analysis of carcasses suggests that a very large proportion (Ph>0.75) of the spawning adults are of hatchery origin (Lindsey 2003, Goodson et al. 2005). The genetic similarity between hatchery fish released (all from outside of the basin) and wild (unmarked) fish is thought to be low. Diversity persistence score = 0.0

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = 2-3.

Habitat Diversity – Although the quality of habitat may be severely degraded the proportion of accessible stream size reflects historical conditions, while much of the elevation diversity has been lost. Although not currently part of the model, considerable changes in the character of the mainstem Willamette River (i.e., loss of side channel habitat and channel braiding). Score (*Order/Elevation*) = 3/3.

Overall Score = 1.0. The small population size of this population and the high proportion of non-local hatchery fish on the spawning grounds were primary sources of concern. Habitat degradation and its effect(s) on life history traits may also be important, but are presently difficult to quantify.

Previously: 2004 TRT 0.64, 2004 ODFW fail, < 4 criteria met.

DV – North Santiam River Spring-Run Chinook Salmon

Life History Traits – Hatchery records from early in the 1900s indicates that spawning began in late August and continued until early October, with spawning currently occurring slightly later (OSHS 1925, Willis et al. 1995). North Santiam River spring-run chinook salmon mature primarily at 5 years old (55%) and 4 years old (41%). Alteration in the temperature and rate of discharge from the Dams has probably had a significant impact on the survival of eggs deposited below the dam. Changes in the temperature regime have resulted in accelerated embryonic development rates and premature emergence. Cramer et al. (1996) reports chinook salmon fry in the North Santiam River moving downstream in late November, in contrast to normal emergence in February or March (Craig and Townsend 1946). Score = 2.

Effective Population Size – The estimated run size for the entire North Santiam River Basin was 2,830 in 1947 (Mattson 1948). The naturally-produced component of the run in 2002 was estimated at 592 fish. Recent estimates of pre-spawning mortality have been high (>50%). Redd counts in recent years, 2000-2004, have be well below 100 redds (Goodson 2005). Score = 1-2.

Hatchery Impacts

Hatchery Domestication – The Oregon Fish Commission began egg-taking operations in 1911 when adults were captured below the confluence of the North Santiam and Breitenbush Rivers, and below where most of the natural spawning areas (except for the Little North Santiam River). The largest egg collection was 13,200,000 in 1934 (this would correspond to 4125 females @ 3200 eggs/female (Wallis 1963)). Between 1911 and 1960, the overwhelming majority of hatchery fish released into the North Santiam basin have come from adults captured from within the watershed, other introduction have come from the South Santiam, McKenzie, and Willamette River Hatcheries (Willis 1963). Analysis of carcasses sampled above Bennett Dam, indicated that only 4, 2, and 8% of the spawners in 2000, 2001, and 2002 (respectively) were naturally produced (Lindsey 2003). On average, the Marion Forks Hatchery collects a small number (< 5%) of natural origin fish to include in the broodstocks.

Genetic analysis of naturally produced juveniles from the North Santiam River indicated that the naturally produced fish were most closely related (although still significantly distinct (P >0.05) from other naturally- and hatchery-produced spring-run chinook from the Upper Willamette and Clackamas Rivers (NMFS 1998). PNI ≤ 0.10. Fitness = 0.35. Score = 1.0.

Hatchery Introgression – Although fish have been introduced from other basins in the Upper Willamette River, hatchery effects/introgression effects were considered in the indirect effects criteria. Score = NA.

Synthetic Approach – A hatchery program has operated in the North Santiam River for nearly 100 years. The influence of hatchery fish became more pronounced with the construction of Detroit Dam, and the loss of the majority of the natural spawning grounds. Currently, hatchery fish account for approximately 90% of the natural spawners (Ph>0.75)—due in part to low natural productivity and a high incidence of

pre-spawning mortality. Additionally, the hatchery incorporates a very low number of unmarked fish as broodstock. Diversity persistence score = 0.5.

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has likely reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = 2-3.

Habitat Diversity – Habitat diversity loss is most severe for this DIP due to the loss of higher elevation spawning areas. Score *(Order/Elevation)* = 3/1

Overall Score = 1.0. Apparent changes in life history characteristics, a small naturally-spawning component and the potential for hatchery domestication were primarily concerns. There were additional factors that could not be quantified for lack of information.

Previously: 2004 TRT 1.00, 2004 ODFW fail, <4 criteria met.

DV – South Santiam River Spring-Run Chinook Salmon

Life History Traits – South Santiam River spring-run chinook salmon mature predominately at 4 years-old (62%) and 5 years-old (34%) (Smith et al. 1987). There does not appear to have been much change in the spawn timing for fish in this DIP, with spawning occurring from August to late September and early October (OSHS 1925, Willis 1960, Wevers et al. 1992). Score = NA.

Effective Population Size – Escapement to the South Santiam River was estimated to be 1,300 in 1947 (Mattson 1948). ODFW (1995) considered that the naturally-spawning populations in the South Santiam River were "probably extinct". In 1998, there were 166 spring-run chinook salmon redds observed in the South Fork; however it was presumed that these are the progeny of hatchery produced spring-run (Lindsay et al. 1999). In 2002, it was estimated that 14% (227) of the spring run sampled below Foster Dam consisted of naturally-produced fish, in addition to 444 fish, 58% of the total, passed above Foster Dam. Currently, surveys count an average of 100 redds each year. Score = 2-3.

Hatchery Impacts

Hatchery Domestication – Wallis (1961) suggested that because of poor husbandry practices, releases from the South Santiam Hatchery did not significantly contribute to escapements (the hatchery may have mined returning naturally produced adults each year). In recent years the proportion of naturally-spawning fish that are of hatchery origin has been over 80% (Goodson 2005). In 2003, over 6,000 spring-run fish were collected at the South Santiam Hatchery, the contribution of natural-origin fish to the broodstock is thought to be small (<5%).

No genetic analyses are available for South Santiam River spring-run chinook salmon.

PNI ≤ 0.10. Fitness = 0.60. Score = 1.5.

Hatchery Introgression – Fall-run chinook salmon are also present in the Santiam River Basin, but the spring-run and fall-run chinook salmon are thought to be spatially and temporally separated on the spawning grounds. Score = NA.

Synthetic Approach – The South Santiam Hatchery has been producing spring-run chinook salmon since 1925. Wallis (1961) concluded that hatchery contributed little to escapements during the first decades of its operation. Currently, a large proportion of returning adults are of hatchery origin (Ph>0.75). The genetic similarity between hatchery fish released and wild (unmarked) fish is thought to be low due to the low proportion of unmarked fish included as broodstock. Diversity persistence score = 0.5.

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = **2-3.**

Habitat Diversity – Although the quality of habitat may be severely degraded the proportion and character (elevation and stream size) of accessible habitat reflects historical conditions. Score *(Order/Elevation)* = 4/3.

Overall Score =1.5. The large numbers of hatchery fish relative to natural-origin fish were a major concern. Additional concerns included small effective population size and habitat mediated changes in diversity (although it was difficult to quantify the later).

Previously: 2004 TRT 1.09, 2004 ODFW fail < 4 criteria met.

DV – Calapooia River Spring-Run Chinook Salmon

Life History Traits – No information available. Score = NA

Effective Population Size – A small run of spring chinook salmon historically existed in the Calapooia River. Parkhurst et al. (1950) reported that the run size in 1941 was approximately 200 adults, while Mattson (1948) estimated the run at 30 adults in 1947. ODFW (1995) considered the run in the Calapooia to be extinct, with limited future production potential. Goodson (2005) estimates that this population is extremely small (<50). Score = 1.

Hatchery Impacts

> *Hatchery Domestication* – It is believed the overwhelming majority of fish spawning in the Calapooia are of hatchery origin (introduced from other Upper Willamette River hatcheries) (Goodson 2005). The majority of the Upper Willamette River hatchery broodstocks have been under culture for extended periods (>15 generations).

> PNI estimate not used. Score = NA.

> *Hatchery Introgression* – Given the preponderance of non-local hatchery-origin fish in this DIP, use of this metric was considered more appropriate than using the PNI. The diversity score was adjusted to reflect the fact that hatchery introduction came from the same stratum. Score = 1-2.

> *Synthetic Approach* – There is no hatchery program in the Calapooia River Basin; however, a large number of Upper Willamette River spring-run chinook salmon (both juveniles and surplus adults) from other hatchery programs in the ESU have been released. Very few redds are observed in the river, and it is thought that natural productivity is very low. The genetic similarity between hatchery fish released (all from outside of the basin) and wild (unmarked) fish is thought to be low. Diversity persistence score = 0.0.

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = 2-3.

Habitat Diversity – Although the quality of habitat may be severely degraded the proportion and character (elevation and stream size) of accessible habitat reflects historical conditions. Score *(Order/Elevation)* = ¾.

Overall Score =1.0. Small population size (the population was considered extirpated by ODFW) and the preponderance of non-local hatchery fish were primary concerns. Other facts may also be important, but sufficient information is not presently available to quantify these effects.

Previously: 2004 TRT 0.70 , 2004 ODFW fail, <4 criteria met.

DV – McKenzie River Spring Run Chinook Salmon

Life History Traits – ODF (1903) surveyed much of the M'Kenzie [sic]. In their report they state, "It has been generally reported by settlers and those living along the river that salmon can be seen spawning during the months of August and September all along the river, but principally from Leaburg post office up to its source." Currently, spring-run chinook salmon ascend Leaburg Dam in two modes, one between May and early July and the other in late August and September. Recent analysis indicates that the majority of fish mature as 5 year-olds (56%) with 44% of the fish maturing as 4 year olds (Lindsey et al. 1997). Score = NA.

Effective Population Size – The 30-year average count of natural-origin fish at Leaburg Dam has been 1,980 (Goodson 2005); however, recent counts have been as high as 4,070 (2004). Score = 3-4.

Hatchery Impacts

Hatchery Domestication – The McKenzie River Hatchery has been in operation for nearly 100 years. During the early years of operation, attempts were made to collect the entire run via a weir at the mouth of the McKenzie River. Husbandry limitations probably minimized the influence of hatchery-origin fish during the early years. Currently, a large number of adipose-clipped, hatchery-origin, adults are prevented from accessing spawning grounds above Leaburg Dam. Analysis of otolith marked fish indicated that 67% (2001) and 55% (2002) of the spawned-out carcasses above Leaburg Dam were naturally-produced (Lindsey 2003). Overall, it is estimated that the hatchery contribution to escapement is approximately 35% (Goodson 2005), although the inclusion of natural-origin fish into the hatchery broodstock is thought to be low.

Genetic analysis of juveniles from the McKenzie River indicated that the naturally produced fish were most closely related other naturally- and hatchery-produced spring-run chinook from the Upper Willamette and Clackamas Rivers (NMFS 1998, see Genetics Appendix). There is very little apparent straying based on the recoveries of CWT fish released from the McKenzie River Hatchery, with more than 97% of all freshwater recoveries occurring in the McKenzie River Basin. PNI ≤ 0.2, Fitness = 0.55. Score = 1.5.

Hatchery Introgression – Relatively few out-of-basin strays are recovered in the McKenzie River. Score = 4.

Synthetic Approach – Of the populations in the UWR chinook ESU, the McKenzie probably has the lowest level of hatchery fish on the spawning grounds. This is due, in part, to the removal of marked hatchery-origin fish at Leaburg Dam and the "relatively" high productivity of the McKenzie Basin. Recent estimates suggest that the hatchery contribution to escapement is 35% (Goodson 2005). In general, there have been few transfers of UWR fish from other rivers into the McKenzie Basin. The McKenzie Hatchery, however, includes few unmarked fish into its broodstock. Diversity persistence score = 1.5

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the

harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = **2-3.**

Habitat Diversity – The proportion and character (elevation and stream size) of accessible habitat reflects is similar to historical conditions, although the loss of higher elevation habitat is considerable. Score *(Order/Elevation)* = 3/2.

Overall Score =1.5. Of the effects that could be quantified, the long term presence of the McKenzie River Hatchery program was thought to be significant. Changes in life history due to the altered thermal regime or changes in the juvenile migratory corridor and downstream rearing habitat could not be estimated due to lack of information.

Previously: 2004 TRT 1.79, 2004 ODFW estimate fail, 4-5 criteria met.

DV – Middle Fork Willamette River Spring-Run Chinook Salmon

Life History Traits – Studies of juvenile emigration from the Middle Fork Willamette River in 1941 indicated that downstream migration occurred on a more or less continuous basis from March through the autumn (Craig and Townsend 1946). Natural production is currently limited and it is not possible to accurately estimate the existing juvenile and adult life history strategies. Currently, hatchery spawning takes place from early September and into early October (Willis et al. 1995). Score = NA

Effective Population Size – There were spawning aggregations in Fall Creek, Salmon Creek, North Fork Middle Willamette River, mainstem Middle Fork Willamette River, and Salt Creek (Mattson 1948, Parkhurst et al. 1950). Collectively, these areas would likely have produced tens of thousands of fish. Based on records from the Willamette River Hatchery (Dexter Ponds) (1911-present), the largest egg collection of 11,389,000 in 1918 (Wallis 1962) would correspond to 3,559 females (@ 3,200 eggs/female). Although Parkhurst et al. (1950) estimated the Fall Creek Basin could support several thousand salmon, by 1938 the run had already been severely depleted. In 1947, the run had dwindled to an estimated 60 fish (Mattson 1948). Construction of the Fall Creek Dam (1965) included fish passage facilities, but passage is only possible during high flow years (Connolly et al. 1992). Recent estimates suggest escapement averages a few hundred fish, depending primarily on what is re-released from hatchery returns. Fewer than 100 redds are normally counted (Firman et al. 2004, Firman et al. 2005). Score= 2-3.

Hatchery impacts

Hatchery Domestication – ODFW (1995) concluded that the native spring-run population was extinct, although some natural production, presumably by hatchery origin adults still occurs. Of the 260 carcasses examined from the Middle Fork Willamette River (including Fall Creek), 11 (4%) were estimated to have been naturally produced (Lindsey 2003). In 2003, 7,340 spring run chinook salmon returned to the Willamette Hatchery, very few if any of there are likely to have been naturally produced. Of the 1,525 fish analyzed at the Willamette Hatchery, only 4 fish were unmarked (Firman et al. 2004). The Willamette Hatchery has been in operation since 1911, and has exchanged broodstock with other Upper Willamette River hatcheries throughout much of this period (Wallis 1962). *PNI ≤ 0.1, Fitness = 0.30.* Score = 1.5.

Hatchery Introgression – Of the 46 CWTs recovered from the spawning grounds, 1 came from the McKenzie River, 1 came from a release of Middle Fork Willamette stock released into Youngs Bay, and 44 came from the Willamette River Hatchery (Firman et al. 2004). Score = 4.

Synthetic Approach – Although historically the Middle Fork Willamette River was a major contributor to the UWR ESU. Currently there is little natural production in this basin, due to the construction of Dexter Dam and Dorena Dam (Row River). The Willamette Hatchery has been propagating spring-run chinook salmon since 1911 and currently releases 1,600,000 yearlings (2006). For the 2002-2004 return years the proportion of hatchery fish naturally spawning ranged fro 72 to 96% (Ph>0.75). The inclusion of unmarked fish into the hatchery broodstock is likely less than 5%.

Furthermore, the hatchery has imported large numbers of fish from other UWR hatcheries. Diversity persistence score = 0.0

Anthropogenic Mortality – Total harvest for catch years 1999-2002, averaged 40.7% for Upper Willamette River populations. Due to the initiation of selective sport fisheries, the harvest impact on unmarked fish is somewhat less than this average. Changes in river conditions in the Clackamas River, Lower Willamette River, and Columbia River and estuary have likely had an effect on juvenile life history diversity. Specifically, the loss of juvenile rearing areas has reduced the contribution of subyearling migrants to the population (Craig and Townsend 1946, Mattson 1962). Score = **2-3.**

Habitat Diversity – The diversity of habitat in this DIP has been highly modified, especially in the relative loss of higher elevation habitats. Score *(Order/Elevation)* = 3/1

Overall Score = 1.0. The small size of the naturally-produced population (the population was considered extirpated by ODFW) and the preponderance of hatchery fish (even though they potentially represent local sources) were primary concerns. The shift in available spawning habitat from higher elevation streams to habitat below the dams was also a concern.

Previously: 2004 TRT 1.21, 2004 ODFW fail, meets <4 of the criteria

DV – Criterion Summary

With respect to the diversity criterion, populations in this ESU were classified into either the 'moderate' or 'high' risk categories (Figure 41) In addition, as the short profile of the diamonds symbols in Figure 41 illustrate, these DV ratings were made with a higher relative degree of certainty than for other criteria (Figures 31 and 40). The loss of genetic resources because of small population sizes, loss of historically accessible habitat and the high incidence of hatchery strays are the primary factors that resulted in the DV criterion population ratings.

The DV ratings and associated uncertainty result in only one population, the Clackamas, being placed into the 'moderate' risk category with confidence. As the diamond symbols in Figure 41 illustrate, the remaining populations are clearly in the 'high' risk category or are borderline between the 'moderate' and 'high' risk classification. Given these results, we conclude the most probable DV criterion risk classification for this ESU is 'high'.
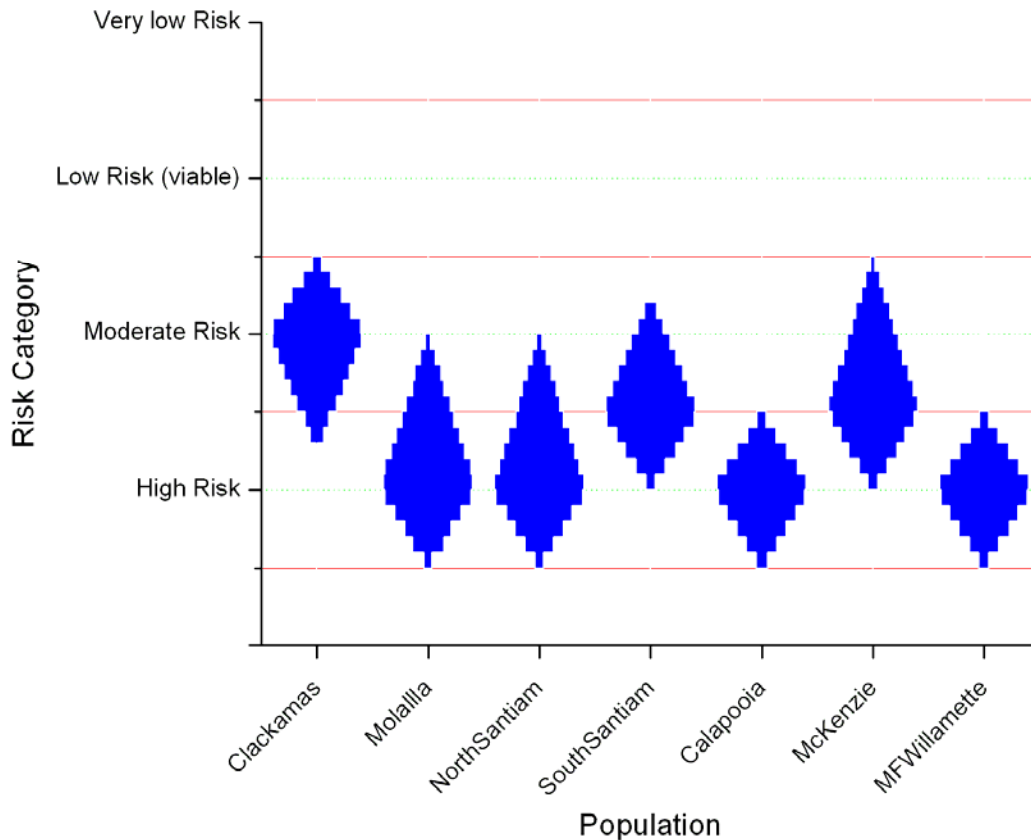

Figure 41: Upper Willamette spring chinook risk status summary based on evaluation of diversity only.

V. Summary of Population Results

The result we obtained when the scores for all three population criteria were combined was that the risk of extinction for UW chinook is high (Figure 42 and Figure 43). The Clackamas population exhibited the lowest extinction risk, being most likely in the 'low' risk category. Five of the seven populations were clearly in the high risk category. In addition, their 'high risk' classification was made with considerable certainty as evidenced by the relatively shortened aspect of the diamonds representing population status. Overall, these chinook populations and therefore the ESU can be characterized as having a high risk of extinction.
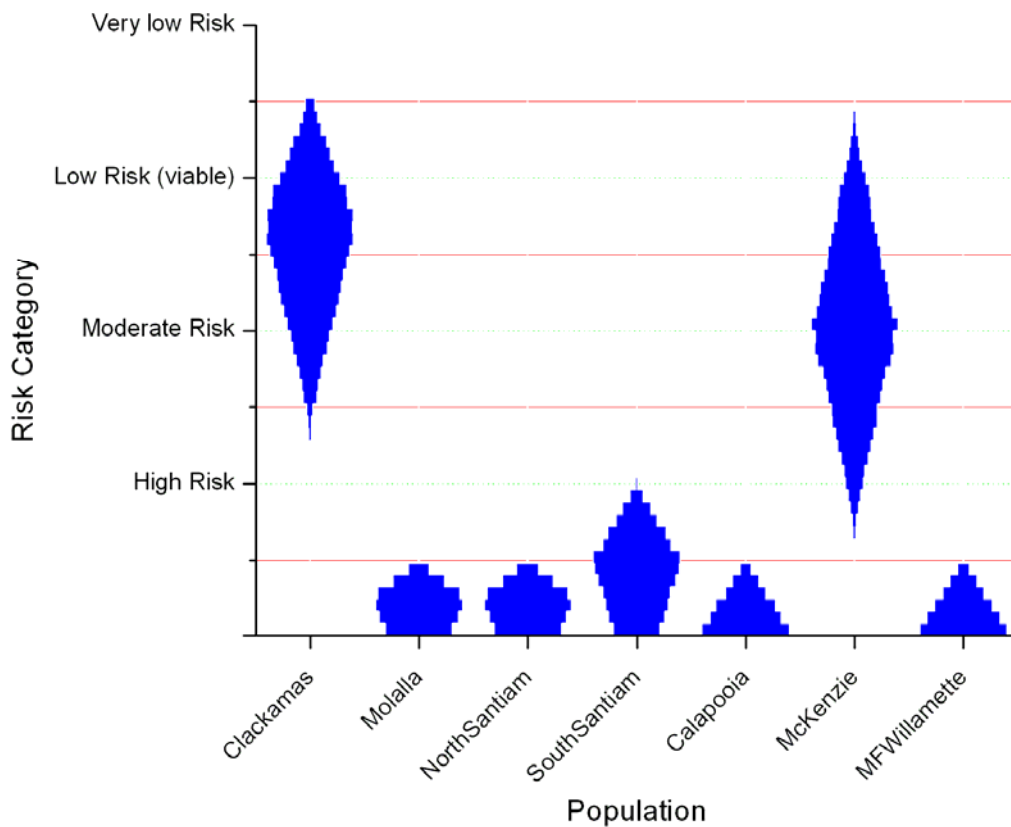

Figure 42: Upper Willamette spring chinook population status summaries based on minimum score method.
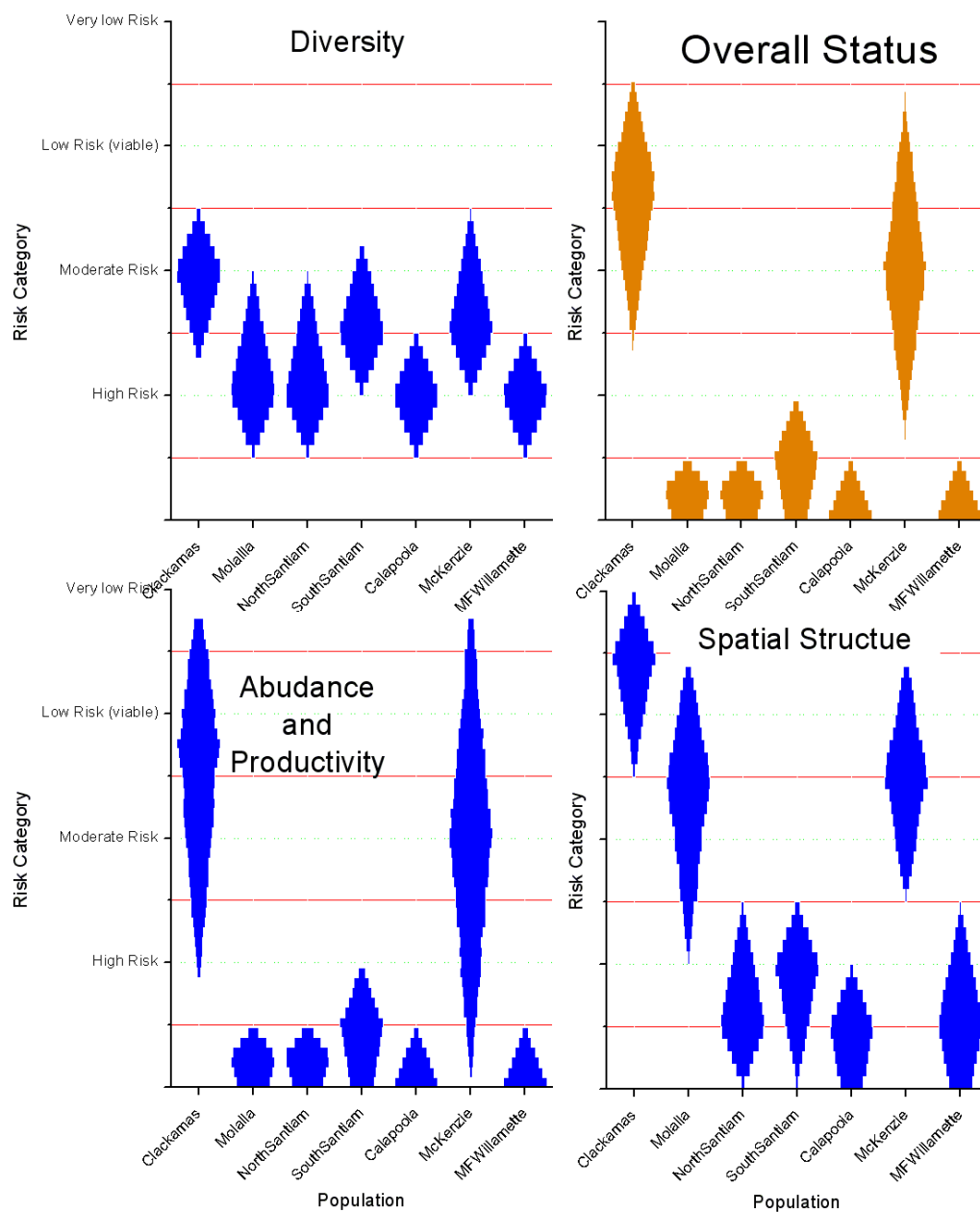
Figure 43: Upper Willamette steelhead status graphs of each attribute and the overall summary.

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